The Journal

OF THE

BOARD OF AGRICULTURE

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Officers should be addressed by their titles, not by their names, to prevent confusion with private letters and to ensure that official letters are opened in their absence.

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or

The Superintendent,
Botanic Gardens,
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The Editor,
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or The Secretary of the Board of Agriculture,
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(1) "Applicants to place in the Colonial Treasury "at deposit account to the order of the Board "of Agriculture the estimated costs of purchase of the animals, their freight, insurance, "and all other expenses of shipment and on "the arrival of the animals here to pay the "Secretary of the Board any cost which may "have been incurred in excess of the deposit.

(2) "Applicants to assume all risks for the animals from the arrival of the steamer conveying them alongside the stelling in Georgetown.

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"The Board of Agriculture will not be responsible for "the character of the imported animals should these not "meet with the approval of the party on whose behalf "they have been imported.

"The Board will also order any seeds or plants of "economic crops on the same conditions."

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A number of complaints have been received, particularly from the country districts, that would-be readers of the "Journal" are unable to obtain copies. Our system of distribution has been made as complete as possible but the demand at many centres has so exceeded the supply that some disappointment has been inevitable. We would point out, however, that by the simple method of

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NOTICE is hereby given that the Stallion "Waterbass imported from the United States of America by the Board of Agriculture, will be stationed for service during the year in Georgetown, Essequibo and Berbice.

Applications for nominations are to be addressed to Government Veterinary Surgeon, c/o Board of Agriculture. The name, age, colour aud height of the mare to be served must be stated, and, if possible the names of the sire and dam. A form will be sent foı this purpose on application as above.

A fee of $5 will be charged for each service, and in every case payment of the fees must be made before service is given.

Each selected mare in Georgetown is to be sent to the Government Veterinary Surgeon, for inspection.

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Waterbass. cost landed in Georgetown $937. is a beautifully proportioned horse. Height, 16 bands, $\frac{1}{4}$ inch; age, 15 years; chest measurement, 5 feet 11 inches; bone below knee, $8\frac{3}{4}$ inches. He is bred on the highest racing lines and is the winner of 16 races value $22,561; he also holds two track records. He is perfectly docile, constitutionally sound, and specially selected for the Board of Agriculture by Mr. H. H. Hunn the well-known authority.

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A space is reserved in this Journal for the notices published free of charge, of any managers, overseers chemists, sugar-makers, foremen, and other agriculturists who may be seeking positions, and of the wants of any sugar planter or manufacturer or proprietor of rice, coconut, rubber, coffee, or cacao estate or of a cattte farm desiring the services of them.

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,, ,,	Shorthorn Bull	60 cents.
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,, ,,	Stallion	$5 00
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JOURNAL

OF THE

BOARD OF AGRICULTURE

OF

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VOL. XX. JANUARY, 1927. No. 1.

EDITORIAL NOTES.

An apology is due to our readers for the late appearance of this number. The delay has been due to unavoidable circumstances. In spite of this set back, we shall endeavour to bring out our April number on time.

An idea seems to have originated in the minds of some persons locally that this journal should have its pages filled with technical articles and the results of scientific experiments. While we have allowed a certain amount of space to be devoted to such articles for the purposes of record, it has never been the aim or policy of the journal to cater solely for these. In order to state clearly what our policy is, we cannot do better than quote from the Introduction to the first volume.

"First of all then our idea will be to benefit the numerous class of small farmers of this Colony by providing plainly worded information and practical advice on various agriculture matters, taking into account local conditions. By means of this paper we shall endeavour not only to show them how to improve their present methods of agriculture but also to inform them of other products worthy of cultivation and how to set about growing them.

"Secondly, it is hoped to interest the sugar planters and owners and managers of other large estates, by bringing to their notice, by means of this journal, improvements that have been effected in the production of their special products on a large scale in other countries, and also by keeping them

informed of the results of the experiments that are being carried out under the Department of Science and Agriculture with sugar-canes, rubber, rice, cacao, etc."

"The various fungoid diseases and insect pests, to the attacks of which all crops are liable at some time or other, will be dealt with in our journal, and, as far as possible, means suggested for their prevention or destruction."

"Thirdly, an endeavour will be made to attract attention and to supply information with regard to the as yet almost unexplored and undeveloped resources of our forests, which occupy an area many times in excess of the lands under cultivation."

We have to admit that there has been some reluctance in the past on the part of local agriculturists and others to contribute articles giving their views and the results of their experiences in the various branches of agriculture in British Guiana. In consequence we have been forced to supplement local contributions by articles culled from other journals when we have satisfied ourselves as to their applicability to this Colony.

We appeal to farmers and others interested in agriculture to assist us with contributions which may be recorded for the use of present and future generations. However, we are assured by the ever increasing number of subscribers and the manifest interest taken in the journal by farmers throughout the Colony, that it supplies a real want in our agricultural community.

An effort is made in this issue to revive and stimulate an interest in agriculture amongst the younger generation. The article on "Boys' and Girls' Clubs," a movement to which we referred in our last volume, indicates where the practice of agriculture should commence. Also the article on "Co-operation" should lead our farmers to realise the necessity for working on this principle if the tilling of the soil, the drainage of the land and the marketing of their crops are to be placed on a sound basis. As was pointed out in our last number, there is room for vast improvement in this direction, and we trust that our farmers will take this lesson to heart, and that it will bear fruit in the near future.

RICE.

By Edgar Beckett, F.L.S.

Rice is a grass—botanically it is known as *Oryza sativa.* It is an annual. Rice has been cultivated for so many years that now the number of varieties is immense. These thousands of varieties differ not only in yield, length of time required for ripening, habit of growth, colour, size and shape of grain, but also in their food value.

The Board of Agriculture has for many years realised the importance of keeping a good grain in this colony, and has for a number of years, carried out experiments both with lowland and upland varieties. The seed padi obtained is distributed to various rice growers every year, and it is interesting to note that, where this seed padi has been distributed the results have been satisfactory.

The necessity for having purity in the strains grown throughout the Colony is very marked. In some districts the writer has observed a red and black grain with "bearded" rice, very predominant. The result has been that, in some districts, the quality of the rice grown is a disgrace to the Colony—broken, red and dark-coloured grain, which is hardly fit for chicken food. If we are to build up an export trade, we must grow padi that will give us a product which compares favourably with the best rice in the world. When it is borne in mind, that our coastal lands are flat clays intersected by deep creeks—with a heavy, impervious sub-soil, it will be seen that in British Guiana, we have ideal lands for growing lowland rices of the very best variety. If drainage and irrigation are assured, we can produce rice which should be second to none, and our yields should be, instead of a paltry 20 bags of padi to the acre, 40 or even more. With respect to these undesirable strains the cultivation of which, it is regrettable to have to state, seems to be on the increase, not only is a most inferior rice the result, but the grains are very weakly attached

to the stalk, with the result that some 15 per cent. of the grain appears to be left in the field when reaping operations are in progress.

Many years ago hybridization trials were carried out at the Botanic Gardens. The flowers were emasculated and pollinated and good grains were obtained.

The rice flower opens early in the morning and usually closes as the day gets warm. Authorities on this subject state that "opening of the plumes and the bursting of the anthers take place more or less simultaneously. According to Van Breda de Haan, an average of three minutes elapses from the opening of the plumes till the bursting of the anthers."—*(The Philippine Agriculturist, August, 1925).*

The work of hybridization, it can readily be seen is one for an experimental station. Experimental work of this nature, as well as careful seed selection, at the various Agricultural stations, where Rice is the prevailing crop of the District, should lead to quicker results, than if these experiments are conducted only at the Botanic Gardens.

Interesting and valuable resuits clearly demonstrable to the growers in the district would awaken amongst them a more intelligent interest in seed selection.

It is of the utmost importance that the bad strains of padi found in the Colony, should be eradicated, and the Agricultural Instructors in the various rice-growing districts are working with this end in view. With inferior varieties gaining ground every year, there is a grave danger of our Rice Industry suffering severely. Rice was cultivated when the French were in possession of this Colony, and it is well-known that runaway slaves cultivated this cereal for food-purposes, in the first year of the 19th and the last year of the 18th century.

Indeed, in 1810, so large a quantity of rice was cultivated by these runaways, on the back lands of Mahaicony, that a special expedition was fitted out to destroy the cultivation.

The 'Sugar-King' William Russel, in 1843, found rice cultivated in Berbice by the Africans, and it is on record that later a company was floated for the cultivation

of rice up the Demerara river. Gradually interest was awakened and the industry began to grow, though not very vigorous it gave signs of promise in the early eighties. Chinese at Anna Regina successfully grew crops of rice, but the industry was not of much importance, though occasionally when there was a shortage of crops in India, renewed activity led to greatly increased areas being planted.

The real development of the industry is, however, due entirely to the indomitable pluck and energy of the East Indian immigrants—in the face of all obstacles they plodded on, until the acreage had risen from 6,500 acres in 1898, to 61,000 acres in 1918-1919.

Just before the War the acreage was roughly 35,000 acres, in 1924 it fell to 29,400 acres, whilst the total area reaped in 1925 was 39,800 acres.

The yields appear to have fallen, as the average yield given in the Report of The Department of Science and Agriculture for 1925, is 15.4 bags of padi. To quote from this Report: " The actual area occupied by Rice cultivation in the Colony was returned at 29,333 acres, of which 10, 557 acres yielded both spring and autumn crops, the area cropped being 39,890 acres. Of the total area, 9,311 acres were used for rice-growing on Sugar plantations. Due to the favourable weather conditions the crop was a fairly satisfactory one, resulting in 38,403 tons, equal to 614,451 bags, of 140 lbs. of padi and equivalent to 23,042 tons, or to 286,745 bags of 180 lbs. of cleaned rice. The yield per acre reaped was at the rate of 15.4 bags of padi. The rice produced was of good quality and 6,918 tons, were exported during the year 1925."—*Report, Department of Science and Agriculture for the year 1925, page 9.*

Apart altogether from poor seed-padi, poor cultivation and inadequate water supply or careless saturation instead of irrigation, two factors, in the writer's opinion, have led to the very small yield obtained. These are—first, the fact that in many instances, the grain is sown broadcast, instead of by raising the seed plants in seed beds and planting them out into the padi beds, with two or three, or even less plantlets to each hole. The average yield prior to the War when this mode was more commonly

practised was 20.8 bags to the acre. When everyone was anxious, during the War, to produce food crops for our consumption and the price of padi increased to over $5.00 per bag, the rice growers wishing to grow large areas and not having sufficient labour available to practise transplanting, simply broadcasted seed over carelessly prepared areas. This habit has not altogether been eradicated. The returns for this period show how poor was the yield per acre. The maximum area under padi was reached in 1919, when actually 74,200 acres were reaped, but the return per acre fell to 15.15 bags of padi. In 1920, 65,700 acres were said to be under rice—the yield was only 10.9 bags of padi to the acre. In 1921, 64,100 acres gave 12.4 bags of padi to the acre. In 1922, 60,500 acres yielded only 9 bags of padi to the acre.

In 1923, the Colony's area was 38,700 acres with a return of 13.7 bags whilst in 1924, 40,270 acres yielded 16.7 bags of padi per acre.

The Instructors point out that wherever broadcast sowing is practised the yields are small.

With the supply of labour such as it is, one may expect that, if the price of padi is on the downward grade the areas planted will correspondingly decrease. In 1927, with the price of $2.00 per bag for padi, farmers will be unable to pay off their advances.—They will re-enter the field when padi prices soar again. The result will be a fluctuating area under cultivation from year to year.

In 1926, many farmers were compelled to sow broadcast so as to be able to "catch" the weather—the long delayed rains having prevented any sowing. The area planted and padi obtained will probably show a very large increase for 1926.

With irrigation and drainage, and with plantlets transplanted from seed beds, our yield should never be less than 30 bags of padi per acre.

The other very important factor which is responsible for such poor yields as 15 or less bags of padi per acre is late planting. Unfortunately this pernicious habit of late planting is persistent and prevalent.

It must never be forgotten that, apart entirely from the question of rainfall, the flowers of the rice plant open only in the early hours of the morning and it is only during those hours that fertilization can take place—when atmospheric conditions are suitable. As the sun rises, fertilization is poor and ceases altogether later on during the day.

It follows, therefore, that the best conditions should be sought for to obtain fertilization. These conditions are generally only obtained by planting not later than the end of April—since the end of June and early in July, is the most favourable time for the fertilization of these flowers. With defective or no fertilization, following on late planting, we are bound to get poor yields. Late planting also requires reaping towards the end of November or during December which means that the harvest has to be gathered in during the rainy season.

Another reason for low yields, apart from poor cultivation and little or no irrigation, is that fields cultivated for a number of years may be lacking in available nitrogen.

This, of course, can be remedied by manuring. It must be remembered, however, that our savannah and creek waters with their heavy burden of organic matter or humus, help to keep rice lands in this colony fertile for a number of years.

There is no reason, if cultivators will secure good seed padi and if irrigation is practised along with proper Agricultural methods, why British Guiana should not top the list of the whole world, as regards yield of padi per acre and rice produced. Whether the export trade was spoilt by the restrictions of a late Administrator or not, or whether, as appears more probable to the writer, the market was marred by the extremely poor quality of rice that was shipped, matters little at the present moment.

Whatever should be concerned with is the getting of a profitable yield and the production of a good grain, so that we may be able to become the granary of the West Indies.

With respect to the depth of irrigation water, experience must be the guide. It must not be forgotten that too much water can be as detrimental, perhaps, as too little.

It is obvious that when the rice plants are young and can furnish for themselves little or no shade, the water must be deeper than when growth has made it possible for the water to be protected from the sun. The regulation of the water supply often has an important bearing upon its stooling possibilites. Drainage must be practised, and if the fertility of the land is to be preserved, the rice straw should be ploughed into the land and not burnt. It is said that the hull ashes from the mills contain 0.82 pounds of phosphoric acid and 0.93 pounds of potash—so that it might be wise to give a dressing of these ashes.

Since the drought there has been a small percentage of plants attacked by various insects—farmers should at once acquaint the Government Biologist if they find their plants attacked by any insects at all. So too, if disease is suspected, the Government Mycologist should be made acquainted at once with any suspicious cases.

So far we have been very lucky—but, as time goes on we may find that our rice industry requires protection from insect and fungoid attacks, and it is better to try to at once nip in the bud any threatening danger. In other rice growing countries the disease known as "Blast"—which is associated with, if not caused by the fungus Perricularia, sometimes is responsible for very serious trouble. We can but hope that we shall not have our rice industry wiped out during any year either by some nsect pest such as root lice or fungus diseases.

Growers must learn to co-operate with the Agricultural Department and make heroic efforts to eradicate worthless padi, to sow only the best seeds and to keep a watchful eye on either injurious insects or fungus disease.

Possibly the Government Fruit, Vegetable and Products Depôt, might be able to assist in obtaining good seed padi for sale to *bona fide* rice growers.

It is pleasing to note that there has been some improvement as regards ploughing and threshing.

In some districts tractors and ploughs have taken the place of Biblical plough and oxen and here and there are to be seen imported threshing machines turning out 120 to 150 bags of padi per diem.

The habit of treading out the grain with oxen is still more common than it should be. This practice is one that should not be encouraged.

The question of using artesian well-waters for irrigation has been investigated by the Agricultural Department. When there is a continuous flow of artesian well-water, it has been stated that five crops can be obtained in 2 years. Well-water, however, would not have the same value from the food point of view as creek or bush water. At any rate the question of utilising this source of water supply should not be lost sight of. We should not rest satisfied until we have such an area in good padi, that our Colony should be responsible for 75,000 tons of cleaned rice per annum. This is by no means a fanciful picture, but quite within the realms of practical politics.

ANTHRAX IN THE LONDON ZOO.

During Christmas two valuable elephants, Indiavani and Sundermallah, died at the London Zoo from a disease which was later found to be Anthrax. It appears that the two animals were fed with some imported foodstuffs and that these foodstuffs contained the deadly spores of anthrax, spores which may retain their vitality for years. One animal died some days before his fellow and a post mortem was accordingly carried out, apparantly too late to be of much use for the cause of death does not seem to have been established then. When the second animal died another post mortem was made and this time the presence of anthrax was definitely established by the microscopical examination of blood smears.

Unfortunately four men who assisted in the first post mortem contracted the cutaneous form of anthrax, known as Malignant Pustule, and had the disease in their case not been recognised sooner than in the elephants the results might have been disastrous. They were treated with anti-anthrax serum with satisfactory results. While anthrax in animals is nearly always internal and fata it generally attacts human beings in the skin through some cut or

abrasion and if treated in time the patient's life may be saved. The older treatment was the complete surgical removal of the lesion but the more modern and more successful treatment is with serum or a combination of serum and surgical treatment.

There is also an internal form of anthrax in human beings and this is very fatal ; it is caused by the inhalation of anthrax spores floating in the air in dust and is usually associated with the wool and hair industries—it is commonly called Wool-sorters Disease. Formerly in Yorkshire when the Health acts and the Factory acts were not so stringent as they are to-day it claimed many victims but it is now much less common.

Cutaneous anthrax or malignant pustule is seen in hide-porters, dock labourers, tannery workers, hide, skin and wool workers, butchers and knacker-men. Foreign hides, wools and hair frequently contain anthrax spores and the disease is caused where such spores gain entry through a break in the skin—thus the disease is usually found on the hand, neck or cheek.

When animals die a sudden and mysterious death on no account should their bodies be opened until it has been ascertained that the cause of death is not anthrax. If facilities for examining blood smears are not available and anthrax is in any way suspected two drops of blood should be taken from the ear and smeared on a piece of window glass or on a microscope slide if any is obtainable. This dried blood may be examined at leisure and provided it is fresh, *i.e.*, within three or four hours of death, a certain diagnosis may be made from it. Having taken a smear, burn the carcase, for it is better to have one's curiosity unsatisfied that one's cow pen or pasture infected.

COHEN MC JONES.

A FEW NOTES ON CANINE DISTEMPER.

The recent decision of the Government to put a tax of $5 per head on female dogs in Georgetown and New Amsterdam may do much to reduce the number of

mangy and nondescript curs that one sees in these towns. Their prolificness is rather surprising when one considers that they have everything against them and that theirs is a continual fight for existence. And yet they multiply! How different is the lot of the imported dog, the pure-bred and often pedigree animal which costing a considerable sum in England, has been brought to the Colony by an enthusiastic dog lover. These dogs enjoy a good home and good food, they are groomed and washed, taken out to exercise regularly and except for the change in climate, one would think that they had everything in their favour. And yet they die! How is it that the stray cur, chased from pillar to post, continues not only to survive but to multiply while the carefully tended pure-bred dog not only rarely reproduces itself but often dies! For most cases the answer is distemper!

Distemper here is an absolute curse to the dog enthusiast, for it appears to attack all imported pure-bred dogs and their locally born progeny with extreme virulence and it is doubtful if fifty per cent. of the animals which develop the disease recover from it. Within the past few weeks the writer has seen several valuable dogs succumb, and this, in spite of the fact that everything possible in the way of treatment and nursing was done for them. Some of these animals were Airedale puppies bred here from particularly good parents and two others were a pair of Alsatian Wolfhounds imported from England a few months ago. In the latter case the owner went to particular pains to save his animals but although one lived for five weeks he eventually lost both.

Unfortunately the present state of knowledge regarding distemper is limited to an assumption that it is caused by a "filter-passing virus" and that the best method of treatment is very careful nursing with treatment of symptoms as they arise. In other words we do not yet know the cause of Distemper nor have we any specific cure for it. Roughly explained, a filter-passing virus is one in which no bacteria can be detected by the most powerful microscope and one which may be filtered through the finest of porcelain filters and yet

remain infective. An emulsion of typhoid or anthrax germs passed through such a filter would emerge sterile, leaving the germ behinds in the fiilter, but a similar emulsion of distemper or small-pox emerges much the same as it went in.

Always associated with the primary cause of distemper are a number of accompanying bacteria which are known as secondary organisms and it is very largely due to these secondary organisms that distemper is a disease of so many complications. Although it has not yet been possible to find a vaccine which will completely minimise a dog against distemper, there has been used for some years a mixed vaccine made from these secondary organisms which does much to lessen the severity of an attack. The use of this vaccine, which is generally given in three doses of increasing potency is often just sufficient to help an animal round the corner. However, it is not of much use commencing this treatment when animals are already sick, and vaccination is strongly indicated when animals are bought in England and before they are shipped to the Colony. Alternately to this, one might purchase in England animals which have already had distemper as they then carry a natural immunity which is generally stronger than the one produced by inoculation.

When a dog becomes sickly looking, and lethargic, refuses food and moves about generally, distemper should be suspected. These are the first symptoms and may be followed by watering of the eyes, slight cough, pimples on the abdomen and offensive breath. Often too, worms are passed and this must not lead the owner to think that worms are the initial cause of the trouble. Most dogs have a few worms inside them and like the proverbial rats fleeing from a sinking ship they leave the animal body when it commences to become unhealthy.

In the treatment of distemper nursing is everything, and the animal is to be kept warm and comfortable in an airy place free from draughts.

COHEN MC JONES.

REVISED ARTICLE ON THE CULTIVATION OF BROOM CORN (SORGHUM DHURRA)

By Fitz Greeves.

In planting broom corn, the soil must be well tilled and drained in order to obtain the best results. Very little manure is needed, because when the soil is too rich, the plant produces a very coarse and undesirable straw for broom-making. The seeds may be sown in drills 3 feet apart, and the seedlings transplanted three or four in a hole 3 feet square, or a very small quantity of seeds may be sown permanently at the same distance, and when the seedlings are about 6 or 8 inches high, the weaklier ones must be pulled out and planted in those places where no seeds have grown.

The plants grow very slowly during the first five or six weeks, during which time they must be kept clear of weeds, but after that, with favourable weather, they grow so rapidly that no further care is necessary. They begin to flower in nine or ten weeks, and three crops can be reaped in one year either by replanting or by ratooning. When the ears come clear out of the sheath, and the seeds begin to swell, they become too heavy and cause the straw to bend under their weight—this natural tendency can be obviated by bending the stalk as soon as the panicle comes out of the sheath. Care must be taken not to break the flower-stalk, as then the straw would not ripen,—this process is known as "tabling." Of course it is only the very long ears that would require this operation. When quality and durability are desired, the straw must be cut green before the seeds are fully matured, and stacked in small bundles in a cool place to be cured by the wind; the sun gives it a brown colour which lessens its value. Straw of a greenish hue is sold more readily and at a higher price than the brown one. In the manufacture of brooms, the brown straw detracts from the quality, and in order to command a ready sale for the article, it is coloured artificially.

There are several varieties of this sorghum, but the best yet introduced are the American, Evergreen, Standard, Acme Dwarf and the Dwarf. The last named grows to the height of about 4 feet, and the straw which is used for making whisks is sold at a higher price than the tall growing varieties. The panicle of the Dwarf variety never comes clear out of the sheath, and consequently, the lower part gets stained by insects if allowed to remain for the seeds to mature. A remedy for this would be to cut the straw just as the seeds are changing colour.

USES.

The straw is used for making brooms, the seeds for feeding animals and poultry, and the leaves and stems make a fairly good fodder.

The seeds when cleaned can be ground into flour and used in the same way as any other corn flour.

Brooms can be made at any price to suit the market and the straw can be grown at a good profit to the farmer.

Brooms are now made in the Colony, and there is a ready market for the straw.

CITRUS FRUIT GROWING IN BRITISH GUIANA.

By Fitz Greeves.

The success or failure of a fruit-growing enterprise depends on what the grower starts with.

There was a time, not so many years ago, when some of the best citrus fruits could be obtained in this Colony, but to-day it is difficult to ascertain where a nice orange or grape-fruit can be found. The fault lies not with the trees, but with the growers. The practice now is to knock down, or pull the fruits from the trees before they are full ripe, and place them on the market in a green state. This deplorable method will be continued so long as a market is found for the unripe fruit. The reason given by most growers for this pernicious marketing is that either the birds eat the fruits, or most of the oranges are of a variety that will not turn yellow. There are only a few varieties of the Citrus family that do not change colour when full ripe, and these are of no commercial value.

What is needed to place this Colony on the same basis as other fruit-producing countries such as California, Florida and South Africa, is real propaganda work; to insist on fruit growers caring their trees, manuring them when necessary to improve their condition and the flavour of the fruits—especially oranges—and teaching the correct methods of reaping and marketing such crops.

Citriculture can be made as profitable an undertaking in British Guiana as it is in any other part of the world if carried on in the right way. The soil is suitable, climatic conditions are excellent and a ready market can always be found for a good fruit. It is unfortunate to have to state that this Colony is far behind other fruit producing countries in methods of propagation. The knowledge is there, but there has been no continuity of practice.

To get the best fruits new methods must be employed in growing them. Commercial fruit growing in South Africa for export dates from only 10 or 15 years ago, and

its development has been due, aside from the suitability of climatic factors, to the up-to-date methods employed. The chief citrus fruit grown in South Africa is the orange, and to-day there is a flourishing citrus fruit trade in that Colony. The last three years have seen a tremendous increase in the production of grape-fruit. The use of grape-fruit as a breakfast fruit has increased wonderfully in the last few years in England as well as in Canada and The United States of America.

In most countries where fruits are grown commercially there is a general drawing away from planting seedling trees, for more reasons than one, and consequently budding and grafting have been successfully and extensively carried on to meet the growing demands for such plants. We have been told over and again that budding is impracticable in this Colony. I say emphatically it is not. The art has been practised in Trinidad and other places with 95 per cent. of success for some time now, and from my experience, it can be done here also.

Better understanding of citrus needed. Conditions in the industry on the whole have not been very satisfactory. The plantings which have been set out in the last few years have largely been done by novices. There are few people in the Colony who have any scientific training in citriculture, and this lack of experience and availability of sound advice has made itself too prominent.

Among the problems to be met at present is the securing of plants of the best varieties and the correct method of planting and caring the trees. It is interesting to note that the insect pests and diseases are practically the same as are found in other fruit-producing countries.

DISEASES.

Citrus diseases have been more encouraged than not, from the fact that most people have been in the habit of mulching their trees up to a foot or more from the roots and have consequently formed a congenial habitat for diseases and pests. This practice should be discontinued

if success is to be achieved. Everything should be kept from around the foot of the trees; even the soil should be removed from the collar roots so as to expose them to light. Collar Rot (Mal-di-gomma) is the most serious of all citrus diseases. Wherever the disease is noticeable, the affected part should be cut clear back to green, healthy bark, and covered with Bordeaux paste. In cases where the trees have been partially girdled, a good method is to build rough boxes around the bases and fill them with clay up to the healthy bark in order to encourage the growth of new roots.

RULES TO BE OBSERVED.

1. Do not try to grow oranges on low swampy land; good drainage is highly necessary.

2. Soil saturated with salt is totally unsuitable.

3. Do not plant oranges or grape-fruits between coconuts.

4. Keep your trees clear of bird vine and other parasitic and insect pests.

5. Hard pruning is unnecessary; only dead wood should be removed regularly.

6. All crown or collar roots should be exposed.

7. Manure at regular periods, especially with Sulphate of Ammonia where procurable.

8. Select your buds from best quality trees.

CO-OPERATION.

CO-OPERATION : ITS PRINCIPLES AND FORMS.*

In the olden days man lived in and worked with nature. He made his own utensils, he formed them in the most suitable ways. He used his thought-power to make them as fit as possible for use, and later on he used his creative power to make them as beautiful as possible. He sang to his work, and the joy in him was transferred from him through his work to his surroundings. He loved work for the sake of the work, and as a result he created good and beautiful things.

Till the beginning of the 19th century, work was done by individuals ; there was no competition ; but every man did his best to create beautiful and useful things. Then the engine was discovered, and as time passed on, the engine was used not for making work easier for the workman, but for one man getting the profit of the work of his fellowmen ; and the economic life of society degenerated into a demoralising routine of monotony. The reason for production was not the demand for goods, but one man's demand for money. No longer do the workers find great joy in their work. Their thoughts are not given to the use and the beauty of the objects they make, but merely to produce the objects. Work which in olden days was the joy of life is reduced to an act of working for wages or profit. That is the level to which humanity has actually fallen.

It is an unhappy circumstance, that people are giving most of their energy and using most of their time each day not to living, not in doing that which would make life worth while, but in earning means which are scarcely sufficient to provide the simple necessities of life. Besides, men are so busy that they have few thoughts left for culture. Well-wishers of humanity are aware of the defects of the

*A Lecture on "Co-operation : Its Principles and Forms" delivered by Miss Anna Ornsholt, D.T. (Copenhagen), at 4.15 p.m., on Monday, the 22nd February, 1926, at the Clive's Hall, Accountant-General's Office, Fort St. George, Madras, under the auspices of the Madras District Educational Council.

profit-motive in industry ; there is running through society a sense of revolt against certain of its injustices, and a hunger for something better has become so strong that it has gvien rise to many schemes both for reform and for radical changes.

There is one movement which is adapting the ancient and natural principle of service to the present economic system. It is called the Co-operative Movement. It is a movement, where the motive of production and distribution is Service, not profit, and in which it is the aim, that the performance of useful labour shall give access to the best reward. The performance of service must be harmonious and equalised with the consumption of things, that is the ultimate function of the co-operative movement.

The ideal co-operative movement should be that, where the craftsman is helped by the society to perform the best work he can, to make the best things he can. His living should be guaranteed, the things he makes should not be sold in the market for profit. They belong to the society for which he works, and of which he is an equal member. The members who use the products of the society pay the price they cost. Work under these circumstances is true service. The worker gets all the value of the wealth they create, minus what is reserved for the social and the common purpose in which he shares. In this way, service is elevated. It would not be possible for an individual by the ownership of property to have more power and escape the performance of service. The ideal aim of co-operation is to set everybody to work : it is to glorify service instead of property, to eliminate the parasites and the exploited proletariat, and by so doing to establish not the dictatorship of the proletariat but the dictatorship of humanity. An important factor comes in as soon as we begin working with co-operation, and that is education, because only those who know can serve. We must prepare ourselves, we must learn, we must be efficient, if we want to help humanity to greater happiness. If we have co-operation on our programme we must have education also. It is never too late to learn, in fact, the whole of life is a school. If we are old, let us start at once with ourselves,

but at the same time let us not forget the children, let us use all our power and our means to give the children education. And how can we serve the world better than by serving the children, who are the future of the world ? In the same way as we serve them, in the same way do we serve the future.

Co-operation rests on the principle that we human beings need one another. We need not only to be helped by others. but we need to help others in order that we ourselves may rise to the highest fulfilment of life.

Let us see what the co-operative method does :

1. It substitutes service motive for the profit motive.

2. It makes impossible the large privileged incomes from rents, interests and dividends.

3. It makes everyone a worker.

4. It makes everyone an owner.

5. It encourage thriftiness and the sense of responsisibility that goes with ownership and that makes character.

6. It sets the people as neighbours working together for their own interests.

7. It substitutes mutual aid for rivalry and antagonism.

8. It trains the people to administer their own industries in their own interests.

9. It wins back for the worker the long-lost control of his food-supply and of his other natural needs.

Each creative mind takes from the past and gives to the future ; each generation stands upon the shoulders of the preceding generation, and we as the present are building the future.

An ascetic once said : " I will go away from the wicked world and live alone." Another man said : " I would be good and happy, were it not for my neighbours." But just as long as our fellowmen are unhappy there is work for us to do ; it is through them, we may find the higher life. They need us, and we need them. So long as our

neighbours have need, our place is with them and not out in the forest. Man belongs where mankind is with its problems and its hungers.

It is not true, that man is hostile to man. The dominant natural tendency is to be kind, sympathetic and helpful. Were it not so, the human race would have perished long ago. It is impossible to follow the light of high ideals without contact with others, who have needs. The great inspirations come from our catching the glimpses of the needs of others.

The co-operative movement stands in contrast to antagonistic spirit. It rests upon the natural and loftiest of human impulses. It is creative and not destructive. It has within it the power to enlarge the sphere of the necessities until its operations shall embrace all that is useful and beautiful. This it proceeds to do, not by restricted and competitive methods of business, but through a movement so wide and democratic, that it invites all the people of the world to join it—irrespective of occupation, race, religion or social standing—and to enjoy equal rights in its administration. No new qualifications are necessary. Everybody as he stands to-day as a consumer is eligible. This movement does not demand an exploited class. It desires that all shall come in. The more who join, the greater is the success. This is the text of its humanity. It creates no privileged class, it is all-embracing. It deals with food, clothing, housing and all the material things that the human beings want. And the most important thing with which co-operation deals is the human being itself. To supply this human being with the things for which it hungers and to place it in a more harmonious relation wlth one another are the functions of co-operation.

There is an impulse which expresses a primitive instinct found buried away in the soul of every individual : it is the desire to serve others, it is a natural impulse. It is suppressed, because it is expensive, but it breaks through the crust of economic determinism now and then and insists on expression. If we want to live an honest life, we must give back to society as much as society gives to us. The un-

balancing of this relation one way or other breeds injustice. In co-operative democracy, the individual discovers that the other members in working for themselves are working for him. Everybody was a common interest. All are serving each, each is serving all. This is the motive which must become universal. As mankind adapts this purpose, humanity will enter upon the era of brotherhood. Society is not organised to promote the best life as long as men find reward in acting selfishly as against the rest of society. The time must come when the individual must ask himself the question : Am I producing good things ? Am I teaching well ? Will these shoes give comfort to those who are going to wear them ? The individual must get away from the idea of producing in the interest of self alone, he must translate his interest into the good of his fellowmen in order that his fellowmen may translate their interests into his good. Man needs not only to bring out the best in himself but also so to act to bring out the best in others. The function of a merchant should be to distribute goods of good qualities to the people who need them, he should not induce people to take goods which they do not need.

Through co-operation, we discover that it is possible for the people to change from self-centred aims to aims that are as broad and wide as humanity. It is slowly driving home by demonstration the idea of a new standard of success. People will have better relation to one another, and the hardness of human contacts will be ameliorated, when men talk more in terms of mutual aid. Co-operation can be lived : it is demonstrating its practical application to-day.

The leaders and most active workers in the co-operative movement in the beginning were working people, socially minded intellectuals, and philanthropists of every persuasion. Many persons of intelligence, who are not satisfied with the state of things as they are and who desire to perform or re-organise the methods of society, have by study and observations been led to look upon the co-operative movement as offering the best hope for the world.

Every country has furnished such workers for the movement from outside the ranks of labour. In some countries these have become the leaders. In Great Britain, Germany, France, Switzerland, Holland, Hungary, Finland and in my own country individuals of the so-called leisure class have been leaders for co-operative movements.

Co-operation cannot progress faster than the people can be trained to understand it and administer its business. It cannot be handed to the people ready made. The co-operators themselves need a large understanding of their movement. Some people say, all that is required of a co-operative undertaking is that it be a financial success, that it saves the people money. This point of view entirely loses sight of the great idea and leaves the minds of the people empty and unsatisfied. Running a cheap store is not a great social aim, it has little social significance. Co-operation truly succeeds only when the people see in it a great social enterprise and are grappled by the desire for justice and the will to make the world a better place to live in.

One of the smallest countries in Europe is my own country--Denmark. It stands out to-day in bold relief because of its prosperity, education and contentment. The force which has chiefly helped to raise Denmark to this position has been co-operation. We say it is the keynote of Denmark. Already 70 years ago, a man named Kristen Kold, inspired by the ideas of his friend Bishop N. F. S. Grundvig started co-education amongst the farmers' children. Several farmers engaged a teacher for their children, and both girls and boys worked together. They did not sit in the schoolroom the whole day, but went out into the fields, the forest, the barn and the stable, and at the same time as they learned the technical side of things, they also saw the practical side of them. This movement expanded and High Schools were built, where the farmers send their young people from their 18-22 year after they had some years of real practical work. It is because of the good and practical education the farmers got, that they took up the co-operative work, and it is from them that the movement expanded. Denmark leads the world in percentage of co-

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operators in its population. Amongst the farmers you will find co-operation in all possible ways. They have their own dairies, sugar factories, banks, and stores, where everything can be obtained, from foodstuff to machinery, clothing, etc. There is one way in which co-operation also works amongst the farmers. In the big farms, they usually have their own thrashing-machines, but in the smaller farms where it would be too expensive to have a machine of their own, some farmers) buy a machine, and during the harvest time this machine goes from one farm to another, every farmer sharing his workers with his neighbours.

Alongside co-operation goes co-education. You will scarcely find a school in Denmark where co-education is not introduced: The children start school when they are 7 years old. Most of the schools are public schools, where children from all different homes meet together. After 5 years' training, the children are divided into two sections, those who are leaving school at 14 years and those who are going in for examinations or for University-training. Here is one thing I want to point out to you and that is, that the children are divided after their capacities and not after the fortune of their parents. If the parents cannot afford to support the children during the High School, they are helped by the school with an annual sum of money. The other children who leave school at the age of 14, are in for a lot of practical work before leaving. The girls learn sewing their own clothes, washing, ironing, darning, cooking. The boys learn wood-work, basket-work, bookbinding and gardening. To every big school, a Doctor is attached. Twice a year, the children are examined by him, their measurement is taken, their weight, etc., and if any child has any trace of consumption, it is sent out into the country to an open-air-school, where the consumptive children are kept, and where they live an out-of-door life. A nurse is attached to that school as well as to the big school in the town and also a dentist. Big baths are built in connection with the drill-hall so that the children can get a shower-bath after their drill lesson, and once a week, they get a hot bath. As almost all the bigger towns in Denmark are situated near the sea, the children during the summer get swimming

lessons instead of drill. In the winter-time, the children, whose parents go out working, get at least one hot meal a day, and homes are provided, where they can stay from 8 a.m. till 6 p.m. where they are taught handwork in the winter and gardening in summer. And all that is done, because in the management of the school there we again find co-operation. The parents and the teachers meet and discuss the problems of the school. After the war, the profit-method of providing houses for people was paralysed, and private building as well as that of Government and Municipalities ceased. But co-operative societies in many countries continued to acquire land and construct houses and thus solving the housing problem for many of their members.

In Copenhagen, we have lots of these co-operative houses. Some of them are big blocks of dwellings on the principal of a hollow square around a garden court, covering about 80,000 to 90,000 square feet.

The buildings are often 5-6 floors high. These blocks sometimes contain over 200 departments, some with 2-3 rooms, bathroom and kitchen, others with 6 rooms, bathroom and kitchen. Each room looks either to the street or to the court. In all these houses, we find electricity, gas stoves, modern plumbing, central heat, white tiled kitchens and fireproof stairs. In the centre of the big court are beautiful flower-beds, a clock-tower with clock-dials facing four ways. At the four corners are the children's playgrounds with swings, sea-saws and athletic bars, in one corner sand-boxes for the smaller children. There are also some sheltered seats, where the mothers or nurse can watch the children. A cement work encircles the garden and play-grounds, and is used by the children for roller skating, cycling or playing.

It is an interesting fact, that the co-operative houses in Europe are better, cleaner, more homely, less expensive and more beautiful than similar houses owned by municipal government ; it is because of the people who live in them, they are the owners of the buildings ,and they themselves run them. In some of the co-operative buildings, there

are also co-operative laundries and restaurants. In many towns, the societies have built small houses each one surrounded by a garden. These houses contain 3 rooms, bathroom and kitchen, and have also electricity and running water. During the war and ever since, the co-operative societies have rented land, and every member who wanted, could get a garden. It is impossible to say, how much good these gardens have done the working classes. On all holidays you could see the whole family out in the garden from morning till night. The man built a little shelter of wood, where the wife could make the food for the family. All were busy working in the garden, and it was a joy for them. The wife and children who were otherwise compelled to live in a flat open in a narrow street, now went out on " their land" as they called it. The man who perhaps often in his leisure hours would go to a restaurant now instead went to his garden. Every day after having finished his day's work, he would go out there and stay till 10 o'clock at night. This of course is only possible in the northern countries, where they have sunset late. I have known people who went to their garden at 3 or 4 o'clock in the morning. I am sure we do not sufficiently realise how much good these gardens have done for the future generation. First, they have kept the father of a family away from the restaurant life with its drinking, and smoking, secondly it has made it possible for the wife to provide cheaper and also better food for the family, and brought many of them away from meat-eating, and thirdly it has made the whole family healthier by giving them opportunity to do out-door work. In the banking affairs we also have co-operation, over 100 banks belong to the Danish Co-operative Bank, which has one of the finest buildings in Copenhagen. Why has the co-operative movement come into existence ? The world is evolving, and if we want to help in evolution, we can do that through co-operation, because it works for happiness and for the good of the many and only what is good for the many can be good for the one. I have spoken to you about co-operation in so many different ways, but we must bring co-operation into every detail in life, if we want happiness. And there is still one place,

which for me seems the most important, where we must work for co-operation, and that is the home. Perhaps some will say " there we have got co-operation," but I am not certain of it. There is only co-operation in a home, where husband and wife work in harmony, otherwise there is suppression on the one side or the other. What is the good of a man working in the outside world for co-operation, if he is not working in harmony with his own family ? What I mean is, a man must recognise a woman's work in the home, whatever it may be, as equal to his own work. I have often heard men saying : " We are the ones who keep up the homes by our work ; we earn the money from which to educate the children. When man says he is making himself superior to his wife, he puts himself on a higher level and forgets that the woman has given her whole life to her work, she bears the children, she it is who makes the home for the children to live in. It is she that makes the future through the children. And what will the future be, if the woman in the home is not happy, if she is not accepted as equal to the man ? It is the man's duty to introduce the feeling of co-operation and equality in the home. The woman is on the same level as the man, and he must let her feel it.

I have been travelling much in Europe because I wanted to know how people lived in the different countries. I lived amongst the people to learn from them, and I found not in one land, but in them all, that where the husband and wife lived and worked in co-operation, there one found the greatest happiness and the best children. If you read history, you will find that where women were regarded as equal to men, there the country developed in every way to a much higher extent than anywhere else. I think myself very fortunate in having been born in a country where women's equality to men was recognised without fight from the women's side.

To make you realise why we should start co-operation in the home, I will ask you to imagine a picture of a calm lake. Throw a stone into the water, and you will see small ripples arise in circles from the place, where the stone touched the surface, and from there spread out un-

broken to all sides. This will happen if you throw the *stone in the middle of the lake, but if you throw it at the* one side, the circles will not continue unbroken and we will not get that wonderful harmony as from the first stone. It is the same with co-operation. We must throw the stone in the centre, we must begin co-operation in the centre of all, "the home." We know from history, that it was the family-life which first came into existence, then the village, county-life and national-life. If we do not start co-operation in the home, we shall not get harmony throughout the village, the town, the county, the nation and at last through the whole world. We must begin in the homes, and the waves will spread out to all sides, we will not be able to stop them, they will reach the shore without great difficulty.

Naturally the woman in the house has her own work, which she must fulfil, but the man must recognise her work as equally important to his, he must look upon the work of his wife, his mother, his sister or his daughter as equally important as his own work outside the house. He must realise that the mother is preparing the future of his country through the children. And how can the future be good and happy if the woman does not work under happy conditions: if she is not recognised by her husband as equal to him, if she is a slave. It is the attitude of the man towards the woman which counts. It does not help her, that she is dressed in beautiful clothes and wears costly jewels, if she is treated as an inferior. The woman must feel herself free, she must have the right over her own body, over her own life, she must have the right to know something about life before she is tied by marriage, she must be an equal to the man, only then will the co-operative movement be of real value to the world. We will find, when we study co-operation, that education goes alongside. In Denmark, we have for many years had co-operation, co-education and women's equal right to men in daily life, and it is perhaps the country, where you will find the least poverty but also very few rich people. Some men perhaps will say "but we do not want the women to take up our work in the outside world." If they think

like that, then they have quite misunderstood the woman's demand for equality. If the man recognises a woman as his equal, she will with her intuitive power do her very best work for her home, and she will feel the happiness, which will expand to those around her and through them again in bigger and bigger circles to the whole world.

We always compare the man with the head and woman with the heart, and we can be sure that the head will not be able to work well, if the heart is maltreated. We must develop equally the head and heart, then happiness will be the keynote of our work, and the terrible poverty which pervades so many countries will disappear. —*The Madras Bulletin of Co-operation*, Vol. XVIII., No. 4.

WATER EXTRACT OF TOBACCO.

SOLUTION FOR SPRAYING TREES.

By Arthur Skibbe, M.A., B.Sc., A.I.C., Assistant Chemist, Elsenburg School of Agriculture, Muldersvlei, Cape Province.

The preparation of tobacco extracts containing an ac quate quantity of nicotine for the control of aphis w undertaken by the Elsenburg School of Agriculture for the benefit of the fruit farmer.

For the extraction of the nicotine a number of solvents can be used, but as the object in these experiments was to prepare a suitable home-made tobacco extract, the writer restricted himself to the one most obvious and suitable solvent, namely, water.

In the preparation of a water tobacco extract the following factors would have to be considered:—

(1) Quantity of tobacco used; (2) the amount of nicotine in the tobacco; (3) the condition in which the tobacco is utilized (e.g. stalks or pods or leaves; also whether

ground or not); (4) the amount of water used; (5) the temperature of the water; and (6) the period of extraction.

In the preliminary work the material extracted consisted mainly of the stalks and pods of Turkish tobacco without any leaves but as the extract produced contained a smaller quantity of nicotine than was deemed sufficient, the raw material was discarded and waste Turkish tobacco leaves substituted.

For the satisfactory control of aphis the Division of Entomology recommends a mixture which will contain from 0.05 to 0.1 per cent. of nicotine; in the case of the stalks and pods, however, it was only possible to obtain 0.015 per cent. by using 2 lb. of waste and 3 gallons of water.

With waste Turkish leaves, however, more encouraging results were obtained, and for the preparation of a home-made mixture it would be advisable to use the tobacco waste leaves and water in the ratio of 1 in 10 by weight (viz., 1 lb. tobacco to 1 gallon of water, or 2 lb. tobacco to 2 gallons water, etc.). When these quantities are used, an extract is obtained which will contain between 0.05 and 0.1 per cent. of nicotine.

EXTRACTS BY COLD WATER OR BOILING

For the extraction either cold or boiling water could be used. When boiling water is resorted to, five minutes would prove to be ample; for cold water, an extraction period of 3 to 5 hours would be sufficient. Where the tobacco is added to water which has just been boiled and then removed from the flame, a quarter of an hour period can be advocated.

To reduce to a minimum the loss of nicotine by boiling, it is advisable to use fairly large vessels for preparing the home-made extract. For example, if home-made mixtures were to be prepared in a 4-lb. syrup tin, a paraffin tin, and a 20-gallon drum respectively, with the same supply of heat for the same period of time, the loss of nicotine referred to above in original tobacco leaves in the 4-lb. tin would be great, while the amount lost from the 20-gallon drum would be inappreciable.

For the control of aphis the solutions prepared either with boiling or with cold water proved equally effective.

In a cold solution the rate of solubility is considerably accelerated by the degree of fineness of the material ; with tobacco dust the maximum solubility takes place after the lapse of two hours.

Although the percentage loss of nicotine on boiling a large volume of water with tobacco in the ratio advocated is small, still the same can be reduced to a very small amount by keeping the water at a simmering heat.

When utilizing tobaccos containing a larger quantity of nicotine the amount of water used for the extraction can be increased, e.g. with Virginia tobacco (analysing 1.50 per cent. nicotine) the quantity of water can be doubled (i.e. 1 lb. to 2 gallons of water), while with Nicotiana Rustica (2.2 per cent. nicotine) the amount of water can be trebled (i.e. 1 lb. to 3 gallons of water). In using these ratios the final extract will contain between 0.05 and 0.1 per cent. of nicotine.

A STRONGER SOLUTION.

A more concentrated extract, which can subsequently be diluted, can be made in the following manner: Into a 20-gallon drum containing 18 gallons of water, 50 lb. of Nicatiana Rustica tobacco are introduced as follows: The water in the drum is heated to boiling and then kept at a simmering heat. Small portions of about 5 lb. at a time are then added to the contents of the drum, which are then thoroughly stirred and allowed to simmer for 5 to 10 minutes. The hot waste tobacco is then removed and dropped into another drum containing cold water. The waste is then squeezed to remove excess water and then discarded. The volume of 18 gallons in the heated drum is kept fairly constant by replenishing the same by additions from the second drum, to which periodic additions of cold water are made. By adopting this procedure it is possible to prepare a fairly concentrated extract, which can subsequently be diluted down. By using 52½ lbs. of Nicotiana Rustica tobacco and 21 gallons of water, the writer was able to prepare in the laboratory an extract containing 0.654 per

cent. nicotine. This extract would have to be diluted down ten times with water if it is used as a spray.

The process itself cannot be repeated continuously because the tobacco itself removes about a third more than its weight in moisture. As the solution becomes more concentrated with the later additions of tobacco, the tobacco itself would tend to remove a large amount of the nicotine on withdrawing same from the simmering drum.

These more concentrated solutions, however, do not keep their strength if retained in a drum with a loosefitting lid. Fermentation and other changes take place which largely diminish the amount of nicotine. A sample of extract which originally contained 0.679 per cent. of nicotine, when allowed to stand for three months and then re-analysed, showed only 0.345 per cent. of nicotine. In other words, nearly half of the valuable nicotine was lost. Perhaps it would be probable that the more concentrated extract would tend to retain its strength if placed into a petrol or paraffin tin, which would then be soldered so as not to admit any air.

SUMMARY OF RESULTS.

1. It is possible to prepare a home-made tobacco extract with cold as well as with boiling water.

2. With cold water the rate of solubility depends upon the fineness and quality of the material. With finely ground tobacco dust a period of two hours proves sufficient, while with leaves, 3 to 5 hours would be adequate. When stalks, twigs, leaves, and pods are taken, an overnight soaking will extract the major part of the nicotine.

3. By boiling or simmering, only 5 to 15 minutes are necessary, according to quality of tobacco.

4. Losses of nicotine by boiling are reduced to a minimum by increasing the bulk of solution and heating so as to keep the water simmering.

5. A more concentrated extract can be prepared by adding successive amounts of tobacco to a boiling-water

solution, and the removal of the wet tobacco after being extracted. This process cannot be repeated continuously, as the degree of the extraction obtainable would depend on the nicotine-content of the tobacco.

6. The more concentrated extract (0.65 per cent. nicotine) loses half of its nicotine on standing in a vessel with a loose-fitting lid.

7. Boiling water to which tobacco is added, and then allowed to cool, extracts the nicotine very rapidly.

THE CULTIVATION OF ANNATTO.

By R. A. Hopkins,

Manager, Experiment Station, Rabaul, Territory of New Guinea.

Annatto, Bixâorellana, is a large quick growing shrub, indigenous to tropical America but grown now in many parts of the tropics. It thrives from sea level to an elevation of 3,000 feet and succeeds in almost any class of soil.

Cultivation. Propagation is readily effected from seed, sown either in nursery beds or directly in the field. In the former case a well prepared and slightly raised bed is made under a light shade. To facilitate weeding and easy handling of the plants the beds should not exceed four feet in width. The seed is then sown in drill six inches apart. When the seedlings are above the ground they are thinned out to intervals of four inches in the rows. Growth is rapid and on their attaining a height of six to nine inches they may be planted out in the field at a distance of 10 to 12 feet apart. Light shade, such as is afforded by a small branch taken from a tree should be provided as a protection from the sun until the plant is well established. In many cases the nursery bed is dispensed with and three or four seeds sown at intervals of 10 to 12 feet in the field. All will probably germinate but the strongest seedling only is allowed to remain in

each hole, the remainder being carefully removed in order not to disturb the root development of the selected plant.

Provided the land has been well hoed and cleaned before planting, little further cultivation is necessary, a periodical weeding being sufficient.

Fruiting will commence under ordinary conditions in about eighteen months from time of planting, and will continue for many years.

Harvesting. The fruit consists of two valved capsules of a dark crimson colour, covered with fleshy spines and containing about forty seeds, the latter being surrounded by a scarlet pulp from which the commercial dye is obtained. Harvesting is done when the fruit capsules have assumed a reddish tinge and appear about to burst. It is advisable to cut that portion of the branch bearing fruit, the object being to keep the shrub at a reasonable height and also stimulate future production.

The fruit is spread upon mats or cloths and allowed to dry in the sun for three or four days. During this operation the capsules burst open and disperse the seed. This should then be cleaned by sifting or winnowing and again placed in the sun. Thorough drying will ensure retention of colour and prevention of mould. The seed should then be packed in double bags and marketed as soon as possible.

Yield. The yield is variable. The average production of dry seed per acre in India is stated to be 500-600 lbs. Reports from the Malay Straits state that 5 cwt. per acre was obtained from the first crop, with expectations of an increased yield as the plants became older. There is every reason to believe that crops grown in this territory would show equal if not better returns.

Advices received from Australia assure a regular market for the product at a price not below £30 per ton and ranging under good methods of cultivation to £40, or perhaps as high as £45 per ton.

Uses. Formerly used for dyeing silks, calico, etc. Annatto is now principally employed as a colouring matter for butter, cheese, and margarine.

ECONOMIC ASPECTS OF PEASANT PROPRIE TORSHIP.

LECTURE BY MR. P. J. THOMAS.

Under the auspices of the Kandy Catholic Club, Mr. P. J. Thomas, Lecturer in Economics at the Ceylon University College, delivered an interesting lecture on "Peasant Proprietorship in its Economic Aspect" recently at S. Anthony's College. The Very Rev. Father D. B. Galassi presided and briefly introduced the lecturer.

Mr. Thomas began his lecture by describing the various systems of peasant proprietorship prevailing in Denmark, Holland, Italy, France, Belgium, Switzerland, the greater part of Germany, and India. He said that in all these countries the peasant proprietor arose and flourished through various favourable circumstances.

In the feudal days of old, most of the land in Europe belonged to the Barons, and the tenants who cultivated the land were merely serfs on the landlord's estate. But gradually under various influences, these serfs became free tenants enjoying some security of tenure, and during the last 100 years, the law had emancipated them and given them full proprietary rights or semi-proprietary rights over their holdings. In Denmark, the peasant proprietary were freed by the legislation of the middle of the last century; and the absorption of peasant properties is now forbidden by law. In France the revolution of 1789 made the peasants real owners of their land which had formerly been burdened by feudal dues; and later much public land was converted into peasant holdings by State activity. Such was the case also in Germany, Switzerland, and Ireland, where today peasant holdings are numerous and prosperous. Ireland suffered for long by insecurity of tenure, but by a succession of land laws culminating in that of 1903, tenancies were converted into ownerships, and to-day few countries can boast of a more prosperous peasantry than Ireland, thanks to the unremitting labours of patriots like Sir Horace Plunkett.

MERITS AND DEFECTS.

The most striking feature of peasant proprietorship was the private ownership of land. It was a well-known saying of Arthur Young that "the magic of private property turns sand into gold." Give an industrious man ownership of even a barren plot of land, and he would by hard and unceasing work make it fertile and productive. As John Stuart Mill has emphasised, family affection was here the chief incentive to industry. But ownership was not wholly beneficial in results. It enabled the peasant to get into debt and led finally to alienation of his land. Privately-owned land was again sub-divided between the children of the peasant and thereby excessive fragmentation of holdings took place. Ownership, again, made the peasantry stick to their small plots of land like limpets on rock and this tended to make society unprogressive. On these grounds it was often thought that life tenancies and other forms of occupancy were more economically profitable than complete ownership. An important subject of controversy at present among statesmen and economists was: Should the small holdings newly-opened be on a tenancy basis or an ownership basis? Much might be said on both sides, but, to the lecturer's mind, it depended chiefly on the nature of cultivation. If the tilling was such that permanent improvements did not count and the size of the annual crop depended entirely or chiefly upon the year's labour, it might be said that tenancy would suit quite well. But in intensive culture of all sorts the incentive of ownership or at least long period tenancy was essential for maximising the output from agriculture.

SOCIAL AND MORAL BENEFITS.

The strongest points that might be urged for peasant proprietorship are social and moral. As already mentioned the peasant proprietary were a source of stability to society and formed the best barrier against revolutionary change. Rural folk were essentially conservative and intensely attached to the soil, and they jealously kept up old customs and clung to ancient institutions. They did not change with every current of foreign influence, and were not easily

cajoled into new-fangled ways. The peasantry also supplied the best soldiers and sailors in most countries. As "The Times" (of London) in a recent leading article put it, "From yeomen's sons came the creative energy which has carried England throughout the world and built up her Dominions and Colonies."

The peasant was not merely the material back-bone of society; he fulfilled a valuable moral function as well. The seething masses of the great cities had little moral stamina, but the countryside made up for the city's backslidings. He (the lecturer) had seen peasant life in three leading countries in Europe and his experience was that the rural folk were religious, hospitable, patriotic, level-headed and had a contempt for the shams of life. They were, along with those magnificent cathedrals and beautiful paintings, worthy remnants of the Christendom of old. United Christendom was no more, but rural Europe might by its moral force yet restore the harmony and beauty that once was Christendom. Salvation come from humble Galilee, and not from proud Jerusalem.

COST OF PRODUCTION.

Perhaps the weakest point about peasant proprietorship was on the side of production. Modern agriculture was based on scientific methods, but the peasant had neither the capital nor the knowledge required to utilise the improved ideas and methods used at present. A large farm could profitably employ the latest methods and most up-to-date machinery and thus produce at a lower cost of production per unit. The small farm could not afford to employ such large-scale methods, and hence could not hold its own against its better off competitor. There was much force in this argument. Modern industrial methods were such that only large units could employ up-to-date and efficient methods, and only by using efficient methods could production become profitable. In other words, farming had become somewhat like a manufacturing industry. However, there were various circumstances which minimised the advantages of the large unit in agriculture. In industry the growth of the unit might be accompanied by

increasing returns, but in agriculture the niggardliness of nature inevitably brought diminishing returns instead, although improvements might for a time put off the tendency. The factors that led to increasing returns in manufacturing industries and thus made for the success of large scale operations were (1) an intensive division of labour due to standardization of the processes; (2) the possibility of concentrating production on one spot; (3) the profitable application of complex machinery; and (4) transport facilities. In agriculture these factors had only a limited application. Agricultual operations could not be reduced to routine, the work varying from season to season and therefore standardization was not possible to any considerable extent. Besides, these operations were spread over a large area, and, as Prof. Fay said, a thousand acres of land surface could not be piled up in a centralised factory. Machinery had therefore got only a limited application in agriculture, most of the processes being done by the hand. These were factors which restrict the advantages that a large farm possessed over a small holding. And this had been found true in practice. Some of the expert witnesses that appeared before the Selborne Committee in 1919 even argued that "the gross returns per acre increase in proportion as the size of the farm diminishes." This may not be true of all countries and all types of farming.

WHERE THE LARGE FARM SCORES.

It has to be admitted, at any rate, that in certain kinds of agriculture, in which machinery has been extensively employed, as for example in arable farming, the large farm had the advantage. In ploughing, drilling, reaping threshing and winnowing, machinery is now employed in wheat growing countries, and, as only large farms could purchase them, small holdings were at a disadvantage, especially where labour was scarce and wages high. This could not be said of other forms of farming—*e.g.*, milk production, vegetable growing, fruit farming and poultry keeping wherein machinery played a relatively small part and close personal super-

vision counted for much. In this field, at any rate, the small holding had succeeded and was bound to succeed.

CO-OPERATION TO THE RESCUE.

Personal care could not make up for the lack of capital and enterprise. The peasantry had less command of capital and spent more for manure and seeds than the large farmer and they usually marketed their produce on less favourable terms than the latter. But the principle of co-operation had come to their rescue. Denmark and Ireland among others, had demonstrated to the rest of the world how the small holders could, by combined effort among themselves, secure the advantages of large scale production and wholesale marketing without losing their individuality and private initiative. Co-operative Credit Societies to-day enabled the peasant to get his capital without resorting to the usurious money-lender and he got it on easier terms, and Supply Societies of various kinds brought to the peasant's door his manure and seeds and feeding stuffs at as reasonable prices as a large farmer can purchase them. In cases where machinery was essential, the small holder could now borrow them from his Co-operative Society. Formerly the peasants got lower prices for their produce, but now the Sale Societies enabled them to stand together like a Cartel or Trust, and obtain the highest prices ruling in the market. Improved methods of cultivation and dairying were being demonstrated to the peasantry by the Co-opeative Societies and Government helped them by imparting agricultural education and by opening demonstration farms and experimental stations. It was thus that the Danish peasant made his butter and cheese with the efficiency of a large factory and the Rhenish peasant grew vine as profitable as his capitalist neighbour. The potato growers of Belgium were to-day marketing their produce at top prices and could easily outwit the middleman.

A HARD LOT.

It had also to be admitted that, except in countries where Co-operative Societies had successfully worked the lot of the peasantry was still a hard one, Owing

to the excessive sub-division of property the holdings of the peasantry had become too small. In France and India, at any rate, the sub-division or *morcellement* has gone to such lengths that land had been 'pulverized' or reduced to atoms (*emiettement*). The peasants were proud of their properties; yet, in spite of their hard and incessant toil, they could hardly keep body and soul together. Their parsimony was such that most of them subsisted on the worst diet possible and lived in their kitchens for economy—all this from rounding off their little holdings with some adjoining bit of land coveted by the family for generations. In these circumstances, it was no wonder that rural life became to some extent mean, "miserable, nasty, brutish and short." As Prof. Marshall remarked, "they sacrificed the end for the means." It was said that many of the paid farm-labourers of England earned better incomes, ate better food and led happier lives than the proprietary peasants of France. Such was the opinion of many travellers in France (*e.g.*, Lady Verney), and even economists like Marshall and Lord Ernle inclined to that view. All economists, however, did not agree. "The so-called low style of living" (of French peasants), said Prof. Cannan, "is superior to that of day-labourers in many countries with large and hereditary estates." Such was also the view of Prof. Fay who had studied the subject at close quarters. He said: "While it may be true that many French peasant proprietors are worse off than the average English farm labourer, it is no less true that some are better off; and it is certainly true that in countries like Denmark and Switzerland the large majority are better off." From the point of view of economic efficiency, therefore, peasant proprietorship has many drawbacks which could not be easily rectified. Co-operation had done much to improve the lot of the peasantry, but co-operation was not all-powerful. The excessive sub-division of holdings at any rate, cannot be successfully grappled with by them. Government, with the help of the community, may be able to root out those evils.

Economic efficiency, however, was not the only criterion by which an institution like the peasant proprie-

torship should be judged; there were social and political considerations which could be divorced from the economist's outlook. It might be, they say, that the peasant proprietor lived hard, worked hard, and yet was on the border line of starvation; but the feeling of independence which land ownership gave him and which made him a useful and self-respecting citizen went a great way to compensate for that. Prof. Marshall gave even greater emphasis to this aspect of the question. He said: "They (small holdings) give to the agricultural labourer a stepping stone upwards, prevent him from being compelled to leave agriculture to find some scope for his ambition, and thus check the great evil of the continued flow of the ablest and bravest farm lads to the towns." Nobody would deny in these days that population was one of the essential elements in national strength. If any one doubted it,let him ask a patriotic Frenchman.

ITS LEGITIMATE PLACE.

Proceeding the lecturer said:—

We have now to ask ourselves the question: What was the legitimate place of peasant proprietorship in the present order of things? I shall for the present, make only a few observations. In the older countries which are thickly populated, there is a real need for fostering small holdings; for, in most of them, there is going on an undesirable overcrowding in towns by the migration of young people who possibly are allured by the cheap cinema and other pleasures of town life. The depopulation of the country-side can only be prevented by finding attractions for the people, nearer home. The small holdings will give them honest and honourable occupation and may solve many of their economic problems. In thinly populated countries where land is abundant and labour dear (*e.g.*, Canada, Australion and New Zealand) there is no such pressing need for a peasant proprietary, and in fact these countries have not yet reared such a class. Small holdings thrive best where land is limited and population is growing. Even in such countries the proper position of peasant proprietorship will depend upon the nature of

agriculture. As alreany pointed out, the farm is likely to be large where cultivation will not be profitable without the application of machinery: where such is not the case the small holding has ample chance. In the case of Great Britain this can be seen well illustrated. When land was used for corn growing small holdings were not wanted; but since vegetable growing, dairy farming and poultry keeping are now becoming profitable, small holdings are increasing, and there is a public desire to have them. It is gratifying to note that even some of the larger land-owners are enthusiastic in this matter.

IN A WELL-ORDERED STATE.

The proposition that corn growing gives the advantage to the large farm has only a limited application in India, because, labour being plentiful and wages low, there is little incentive to the employment of labour-saving machinery. It is not desirable for any country to have exclusively, either large farms or small holdings. In a well-ordered state there must be both kinds of culture. National life will be strengthened by a greater diversity of tenure and types of holding. As Prof. Marshall points out, "there is public need in every district for small holdings as well as large; for allotments and large gardens; and generally for holdings so small that they can be worked by people who have some other occupation." The proportion of large and small holdings in any country should, it seems to me, depend upon (1) the nature of farming, (1) the density of population and (3) the specific social and economic needs of the country. All attempts, by the community or Government, to increase the variety of holdings will certainly increase national welfare. Where small holdings are fostered by Government, it is necessary that it should take special precautions against excessive sub-division of holdings as also against their excessive consolidation. Both are evils to be avoided, if possible, by statutory enactment. Government will have also to decide as to whether ownership or tenancy will suit the needs of the kind of people for whom provision is is being made. Above all Co-operative Societies for credit supply

and sale should be provided and placed on a secure basis, for, it would be futile to open small holdings without such institutions. There is no doubt that on the whole co-operation is the greatest hope of the peasantry in every country and in all circumstances.

MR. STOCKDALE'S REMARKS.

Mr. F. A. Stockdale in proposing a vote of thanks to the lecturer said that they had to thank Mr. Thomas for his interesting lecture. He had depicted the history of agricultural development in England, and had very fairly laid before the house the advantages and disadvantages of peasant proprietorship. He (the speaker) did not intend to dwell on the manner agriculture had developed in the West. In Ceylon, following the lessons taught them by Western methods, the people had acquired wealth by opening rubber and coconut estates. Now Ceylon was thinking of ameliorating the lot of the villager, by starting a system of peasant proprietorship. It was thought that the millenium would be reached once the system of peasant proprietorship came into working order. But only careful and close organisation would bring success.

Mr. Stockdale, continuing, said that in peasant proprietorship, the sub-division of land should not be overlooked. In Ceylon it was difficult to stop the villager from parcelling up the land. Therefore when a system of peasant proprietorship was established there should be legislation to prohibit partition. At present one did not know how to work out the problem. He wished the lecturer had gone into the question to suit the local conditions and contrasted the Western conditions with those prevailing in India. As in India Ceylon was confronted with the problem with no basic data to work on. The speaker said that the conditions of the small man had changed for the worse after war especially in imported articles. In conclusion Mr. Stockdale said that the lecture should stimulate an interest in the subject.—*Ceylon Observer.*

BOYS AND GIRLS' CLUBS.

TO BRIGHTEN FARM LIFE AND STIMULATE THE INDUSTRY.

By E. J. Shorten, Division of Agricultural Education and Extension.

The question of securing an adequate food supply at reasonable prices and the economic export of any surplus production, is one of first importance in any country. Therefore a sound and efficient system of agriculture is a universal necessity.

One of the foremost means of meeting this necessity is the wise forethought that provides for the adequate education in his rural school of the farmer of to-morrow so that correct principles of agriculture are instilled from youth in the future farmer. An efficient and inexpensive way of securing this end is through the medium of boys' and girls' clubs. Happily, a movement in this direction has recently been started in South Africa.

AIMS OF CLUBS.

The aims of this movement are, briefly—

(1) to foster a love for rural life and make conditions pertaining thereto more attractive ;

(2) to educate in accordance with approved modern agricultural methods ;

(3.) to combine the interests of teachers, parents, and children ;

(4) to develop self-help and teach the dignity of labour ;

(5) to enable school children to secure good stock and seed and to teach the proper use thereof ;

(6) to develop the social amenities of the countryside ;

(7) to demonstrate to the community the lessons learnt in better home and farm practices.

A PIONEER COUNTRY.

The United States of America has made a feature of this branch of agricultural education, and there are hundreds of clubs throughout that country. The movement is subsidized by the Government and by various local bodies. In each county it is under the control of the Agricultural College, and the country agent does the work of organization. Each club has its club leader, secretary, etc. Members of these clubs have to buy all their requirements.

THE MOVEMENT IN SOUTH AFRICA.

In South Africa a begining was made in 1914 in the form of the Boys' Maize-growing Competition under the direction of the Department of Agriculture. This has now grown into a wide and interesting competition, but is almost solely confined to the Transvaal Province. It was formerly administered from the Potchefstroom School of Agriculture, but recently its control was transferred to to headquarters, Pretoria, with a view to extending the field of its operations. The success that has met this competition and the experience of other countries leave no doubt as to the great influence these agricultural clubs have in developing a "farming sense" in children.

In the ordinary course the great majority of our children in rural areas will become farmers or in some other capacity derive their livelihood directly or indirectly from farming. The aim then should be early in life to give them an agricultural bias and to instil a knowledge of the best methods of farming.

GOOD RESULTS OBTAINED.

The Education Department realizes this, and is actively engaged in furthering this object. We can already claim that much has been achieved in this direction in the case of maize-growing. For twelve years the competition, referred to above, has flourished, and wherever the boys have entered, there has followed an increase in production in that area, due to the introduction of better methods and better seed. Yields of twenty bags to the acre are not uncommon, and are often exceeded.

Such a competition, with its 600 entrants, means that there are 600 demonstraton plots distributed over the maize growing areas, resulting in a wide dissemination of the knowledge most required by our maize-farmers, including the use of better seed.

Other branches of farming may similarly be encouraged, such as in poultry, garden crops, pigs, and calves. It is the surest way to increase quality production.

There are three essentials in the success of a club :—

(1) The members have to do all the work themselves.

(2) A clear account of costs and work done must be kept.

(3) Nothing is to be issued as a free gift to a member. Donations in cash or in kind for the purpose of starting a club are to be viewed as a joint liability of the members of the club. The liability must be discharged from the subsequent returns of members, on a percentage basis. Whether the repayment is made to the original donor or is merely placed to the credit of the club, must not effect the principle. The club member must realize at the outset that having been afforded the means of acquiring material gain, it is a first duty, indeed a debt of honour, to make good in a practical manner his indebtedness to the person or other source which provided such orginal means. This will not only inculcate a sense of gratitude, which is so morally essential in our dealings with one another, but will develop the business-sense, which again is so essential to material success.

PROSPERITY LEAGUE CLUBS.

The Transvaal Agricultural Union inaugurated the Prosperity League Clubs some years ago. This praiseworthy scheme has met with a certain measure of success and is supported by the Transvaal Education Department and the Union Department of Agriculture. It is felt,

however, that greater success would follow a closer collaboration between these bodies.

Hitherto no definite aims have been laid down; and no printed literature—so necessary and helpful to those interested in the movement—giving general information and detailing the various projects that may be put into operation, has yet been issued.

PAMPHLETS PREPARED BY THE DEPARTMENT.

The Division of Agricultural Education and Extension of the Department of Agriculture has now, however, prepared a series of pamphlets covering several of these projects, viz.: maize, vegetable growing, pigs, calves, and poultry. These pamphlets are available for distribution to Prosperity League Clubs and to other schools wishing to start such clubs.

It is advisable that each school concentrate on one or two lines only. The members of a club may, however, undertake any project they like, but for the sake of competition it is desireable that a sufficient number should embark on the same projects.

The larger agricultural societies are very keen on encouraging these clubs, and generally make provision for such competitions. As these clubs increase in number and usefulness the societies will undoubtedly evince greater interest and give more opportunites and prizes for competition at their shows.

In the Transvaal any clubs that are formed should be affiliated with the Prosperity League. In order Provinces they should, if possible, affiliate with the nearest farmers' association or agricultural society.

VARIOUS PROJECTS OUTLINED.

The following is a brief outline of some projects :—

Poultry.—Each member to set at least two settings of any approved pure-bred variety, and to feed and house according to modern methods. Local breeders should be approached to donate settings of eggs to the club. This project to start in the late winter or early spring and a

show to be held in the autumn. Costs and full records to be kept of work done. The following season this project can be continued as a "laying test" project.

Dairy Calf.—Donation of suitable heifer calves to be obtained from local breeders and to be drawn for by lot. Each member to feed the calf according to directions. All the work in this and every project to be done by the member. Full details to be kept of feeds used. To be exhibited at the school show.

Gardening.—Each member to grow a certain area of vegetables or flowers. Full details of costs, sales, etc., to be kept and a show arranged at the most suitable time.

Maize.—To be according to the present Boys' Maize Competion. This project differs from the others in that substantial cash prizes, cups, medals, etc., are offered for *competition.*

Silkworms.—In areas where there are mulberries of the correct variety, this should be a popular project. Silkworm eggs and advice may be had from the Department of Agriculture.

Pigs.—Weaners to be obtained and cared for as for calves.

Any of these projects may be carried on as a "group project" at the school, and it rests with the ingenuity of the teachers and parents to raise the funds necessary to commence these clubs and to collect prizes for the shows.

It may be mentioned here that this year agricultual demonstration plots for public schools were established under the supervision of Miss Alper, of the Division of Agricultural Education and Extension. These plots are situated at the schools, where fertilizing, seeding, and other demonstrations in agricultural practices are conducted. This kind of group or club work is proving to be very popular as it provides a definite project.

TO FORM A CLUB.

The teacher must call a meeting of his staff and pupils and any others interested, such as parents, members

of the local farmers' association, etc. A chairman and secretary-treasurer must be elected, preferably teachers, and from amongst the pupils three committee members. Then it must be decided which projects are to be undertaken and how funds and donations of poultry, stock, etc., are to be obtained. The secretary must thereafter communicate with the Chief, Division of Agricultural Education and Extension, Union Buildings, Pretoria, stating the total number of members, and how many have entered for each project, giving names and ages.

All available pamphlets on the subjects chosen as projects will be provided, also a suggested constitution, which may be amended so as to suit local conditions.

Club meetings should be held at least once a month, and must, of course, be conducted in an orderly manner. To maintain interest it is strongly recommened that at every meeting a short lecture be given by a qualified person, such as an extension officer, local farmer, or the teacher.

Success depends on the enthusiasm of the teachers in the project and their tact in dealing with the parents.

The Department of Agriculture earnestly commends the movement to farmers, teachers, and others interested in the rural areas and the development of our agricultural industry. It is ready to render every assistance in aiding the movement and invites inquiries. These should be addressed to the Division of Agricultural Education and Extension, Union Buildings, Pretoria, and be marked "Prosperity League Clubs."—*Farming in South Africa.*

THE SUGAR INDUSTRY IN SOME OF ITS CHEMICAL ASPECTS*

By Dr. C. A. Browne†

Probably no other food commodity has had so strong a fascination for the economist, the agriculturist, the chemist and the engineer as sugar. In the first place, no other food product has been so frequently subjected to tariff laws, bounties, cartels, and other regulations. In the second place, the operations of producing sugar cane and sugar beets are the best examples of a system of agriculture which, although highly specialised, is probably unrivalled in the extent and complexity of its relations. In the third place, sugar is the only food commodity which is supplied to the consumer in a state of complete chemical purity, the removal of the last traces of contaminating material thus acting as a continuous challenge to the ingenuity of the chemist. Lastly, the numerous operations of sugar manufacture present a greater variety of attractive problems to the engineer than is offered by any other branch of industry. Chemists distinguished in other fields, like Sir William Crookes, have gone out of their way to write treatises upon sugar manufacture, and engineers distinguished in other fields, such as Sir Henry Bessemer, have gone out of their way to invent new machinery for the extraction of sugar. Important epoch-making appliances, like the vacuumpan and multiple effect, now used extensively in all branches of applied chemistry, found their first industrial application in the manufacture of sugar.

Engineers and chemists have too often neglected the agricultural side of sugar production. The costs of planting, cultivating, fertilising, and harvesting make up over two-thirds of the total cost of a pound of sugar, thus leaving less than one-third for the expenses of manufacture. Sight has often been lost of the fact that the cane or beet plant is the real sugar factory, the extraction, evaporating,

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*Read before the Montreal Section on January 18, 1926

†Chief, Bureau of Chemistry, U.S. Dept. of Agriculture.

and crystallising equipment being simply the means of separating the sugar that nature had already produced. The neglect of the more important agricultural chemical processes in the field, where the sugar is synthesised by the plant from its elementary constituents, is of far greater moment than an attitude of indifference to the chemistry of factory operations.

THE SOIL AND THE CROP.

Chemistry assists the agriculture of sugar production in determing the character of soils and fertilsers, the varieties of crops, and the conditions of cultivating and harvesting which are best suited for obtaining a maximum yield of sugar per acre. Surprisingly little attention has been given to the soil when selecting the sites of some tropical sugar plantations. A newly created plantation in the West Indies with a most expensive modern factory equipment was brought to the verge of ruin through failure to determine in advance the character of the land. The soil proved to be very salty, with the consequence that the sugar cane grown upon it yielded juices of extremely low purity, and so heavily charged with soluble chlorides that profitable sugar manufacture was almost impossible. Extensive drainage has been required to free the fields of this plantation from their excess of salts, and to bring them into a condition suitable for successful sugar production. A preliminary survey of the undeveloped land by an agricultural chemist would have prevented the initiation of such a costly mistake.

The proper treatment of soils where there is a dangerous accumulation of soluble salts is a problem which the growers of sugar crops (both the cane and the beet) must occasionally consider. In the alluvial cane lands of Demerara, Mr. Maurice Bird has found the soil solutiou to contain at times over 1% of soluble mineral matter, consisting of the chlorides, sulphates, and carbonates of sodium, potassium, calcium and magnesium, which tend to accumulate in the surface soil as a result of capillarity and evaporation. This enormous excess, due partly to the concentration of soil water during protracted droughts, may result

in serious damage to the growing crop by causing a diseased condition of the cane known as withering. The dissolved magnesium salts are particularly toxic to the cane unless their influence is counterbalanced by the favouring action of sufficient calcium bicarbonate, for producing which a rich supply of decomposing organic matter is needed in the soil in order to supply the necessary carbon dioxide.

In order to facilitate the removal of salts from defective cane lands it is sometimes advantageous to break up the subsoil to provide better drainage. Periodic flooding of the land is also beneficial. The chemical processes of oxidation, hydration, and nitrification advance with great rapidity in tropical soils, the elements of plant food being made available in a much shorter period than in temperate zones. This would be a great advantage were it not that the forces which impair fertility are equally rapid. As one result of these chemical changes the soils of the heavy clay sugar lands in Demerara become markedly alkaline during cultivation, a condition made evident to the eye by the solution of humus which colours the drainage waters a dark brown. It is imperative for the maintenance of fertility that the organic matter removed by oxidation and leaching be fully restored.

A peculiarity of Demerara sugar cane juices and sugar-products, to which Professor Francis, the former Government analyst in British Guiana, called attention forty years ago, is the low optical activity of the reducing sugars. I discussed this interesting question, when I visited Demerara seven years ago, with Sir John Harrison and other scientists. Mr. Maurice Bird attributes the phenomenon to the alkaline condition of Demerara soils, the effect of dilute alkali being to bring the polarizing power of a mixture of reducing sugars to the point of inactivity. Owing to this characteristic of Demerara raw sugars, some refiners, because of the loss of the favourable differential between direct polarisation and sucrose content, which with the raw cane sugar of other countries amounts to several tenths of one per cent., have held that it was less profitable to refine sugars from this colony. The high purity of the Demerara raw sugars, however, nullifies this apparent disadvantage,

which, it should be stated, is not equally pronounced at all seasons.

The value of chemical analyses of soils as a means of determining their toxicity is generally unquestioned, but there is a wide difference of opinion as to the value of such analyses as a means of determining the manurial requirements of a sugar crop. So many factors enter into the question that deductions from soil analyses in one location do not apply to similar analyses in a different environment. It may be said, however, that for a given region of similar agricultural and climatic conditions, soil analyses, when made in conjunction with carefully conducted field experiments over a period of years, make possible the formulation of certain general conclusions as to fertiliser requirements. Thus *in Hawaii it has been observed that if the amount of* P_2O_5 dissolved from a soil by a 1 per cent. citric acid solution exceeds 0.004 per cent. with an accompanying quantity of 0·15 per cent. soluble lime and silica, no response is obtained when phosphatic fertilisers are applied to sugar cane. In the same way it has been observed that soils with a citric acid soluble potash content above 0·03 per cent. and a fair amount of accompanying soluble lime do not generally give increased yields of sugar cane with applications of potash fertilisers.

THE NEED FOR NEW VARIETIES.

While the production of new varieties of sugar cane and sugar beets is a subject that falls within the realm of plant breeding, the selection of the particular variety of best composition for sugar production devolves largely upon the chemist. The need of constantly improving the existing varieties of our sugar producing crops is always dominant. Certain established varieties may give good returns for hundreds of years, and then show a sudden degeneration from failure to resist new diseases. Thus the old Bourbon variety of sugar cane, which for centuries had been the chief source of the world's sugar supply, began to decline in vigour about forty years ago, and to succumb to the attacks of fungous diseases. The yields of cane fell off enormously, and the sugar industry of the

West Indies would have been ruined, had Harrison and Bovell, in Barbados, not discovered at this time the fertility of sugar cane seed, thus opening the way to the production of new varieties that were resistant to fungus disease. But now another malady of the sugar cane, the mosaic disease, has appeared, and, as the fungus-resisting canes are not immune to this new enemy, there has arisen an urgent demand for harder varieties. Considerable success has already been obtained in producing canes which are resistant to disease and cold. During the past five years the Louisiana Experiment Station has been conducting experiments upon the growing of sugar beets in different parts of the State. The results of the preliminary work indicate that beets planted in November are ready for harvesting the following May, with a yield of about 20 tons of roots to the acre, a sugar content of 12·5 per cent. and a purity of over 84. If a beet crop can be harvested in Louisiana in May—June, and a cane crop in November—December, the economic losses from idle factory equipment will be greatly reduced.

SOURCES OF LOSS.

One of the most serious chemical losses in both the sugar cane and sugar beet industry is the destruction of sucrose in the crop between the time of harvest and manufacture. This loss may result from the inverting action of enzymes after the cane has been cut, or from the fermentation of the crop as a result of injury by freezing, insects, and other causes, or from the natural processes of cellular respiration which take place in all stored plant materials. In the tropics, where sugar cane is sometimes transported long distances, a week or more may elapse between the times of cutting and milling, with the result that under the favourable conditions for bacterial growth the stalks reach the mill in a state of deterioration, the expressed juice being sour and slimy from the presence of acid and gummy decomposition products. The clarification of such juices gives the factory chemist a vast amount of trouble. With very badly fermented cane, sugar making is an impossibility ; working up the juice into industrial alcohol is the only hope of salvaging anything from the wreck.

It has been estimated that the actual destruction of sucrose from cellular respiration during the storage of sugar beets, between digging and slicing, amounts each year in the United States to $5,000,000, and that another $5,000,000 loss occurs in the factory owing to the inability to recover as much sugar because of the accumulation of objectionable nonsugars which have been rendered soluble by metabolic changes in the beets during storage.

The saving of the immense losses which result each year from the deterioration of sugar cane and sugar beets has long engaged the attention of chemists. Immediate dehydration of the sliced stalks and roots has been proposed, the advocates of this scheme holding that among other advantages the dried material can be pressed into bales and preserved for an indefinite period before being worked up for sugar, thus enabling the sugar factories to operate all the year instead of for only a few months as at present. The insufficient margin of profit in dehydrating sugar cane and sugar beets at the present high cost of fuel and low selling price of sugar has been the most serious obstacle to this process of sugar manufacture.

PLANT.

Leaving now the agricultural side of our topic, it remains to discuss raw sugar manufacture in some of its chemical aspects. Manufacturers of sugar have probably been more imposed upon by the purchase of undeveloped and impracticable patented processes and appliances than have those of any other product. It is instructive to visit the sugar factories in Cuba and other tropical countries, and to note the expensive equipment discarded after a brief period of use as uneconomical or useless.

The sugar planter has always shown willingness to adopt any suggested improvement, whether it be a new appliance, such as a filter press or evaporator, or whether it be an entirely new process of manufacture. When the new scheme is backed by capital and well-organised propaganda, the isolated manufacturer is almost helpless if he desires to ascertain the disadvantages of the proposed innovation. Trade publications, whose colums should be thrown open to a free discussion of the pros and cons of

every process, are rarely useful in such an emergency. What is needed is a forum of open public discussion in which both the successful and unsuccessful users of the process can state their experience, for it is only upon the basis of widely disseminated experience that progress can be made. Too often in cases of this kind the purchaser has been sold a problem instead of a well-developed process. Many engineering chemists can no doubt recall in their own fields instances of a hastily exploited device in which the basic principle was sound, but the mechanical or technical development was so imperfect that after it had been tried upon the manufacturing public the original appliance had to be entirely changed.

One thing which always impressed me, during my occasional visits to tropical plantations, was the wonderful durability of the old British sugar-house machinery. I have seen in operation walking beam engines and other appliances that have been in constant use for over 80 years. In commenting once to Sir Francis Watts, the former Imperial Commissioner of Agriculture in the West Indies, upon the excellent lasting quality of this old Scotch and English sugar-house equipment, he remarked jokingly that it was too good, as the purchase of machinery which will never wear out, and which its owner, therefore, will never care to replace, is not always the best economy Indeed, some hold that the building of appliances to last for more than 20 years is an extravagance, as new, more economical devices which have been perfected should then be installed in their place without further delay. Machinery built for a short existence, however, has the frequent defect of structural weakness, and the heavy over-burden which sugar making equipment must sometimes bear, demands the most durable kind of construction. This is particularly true in the case of sugar mills, which in grinding the new mosaic-resisting varieties of cane with high fibre content are subjected to enormous strains, far exceeding anything that the designer of these mills imagined

The tendency of late years has been towards increasing the crushing, shredding, and rolling capacity of sugar cane mills. This is largely due to the desire for bette

sugar extraction, but it is also partly the result of an effort to obtain a more closely matted blanket of bagasse far retaining the clarification mud, which in certain processes of manufacture is pressed out between the rollers of the mill. High pressure crushing and milling, however, has brought in its train a number of disadvantages. Much of the bagasse is reduced to a fibrous powder, which finds its way through to the final sugar, and by its moisture retaining capacity exerts an undesirable influence upon the keeping quality of the product. High milling also removes more of the gums and other collodial impurities of the cane, thereby increasing the difficulties of clarification.

Colloidal Impurities.

The U.S. Bureau of Chemistry during the past few years has devoted considerable study to the colloidal impurities of sugar beet juices, the removal of which is the most fundamental process in sugar manufacture. The accurate determination of all the colloidal impurities in juices, syrups, molasses, massecuites, and sugars is a somewhat difficult procedure. The Bureau of Chemistry has employed *ultrafiltration* by means of standardised collodion membranes as the most suitable means of separating colloids for quantitative determination. These membranes will retain not only all the material which is held by the filters of the sugar factory, but also the minutely divided colloidal particles that pass through. The results of such determinations upon the successive washings of different sugars showed that the colloidal impurities were distributed rather evenly throughout the crystals, which would indicate a continuous absorption of impurities of this type upon the surface of the growing crystals while in the vacuum pan. It is evident that no manner of washing a sugar in the fartory centrifugals will free it from the contaminating colloidal impurities.

The "water soluble" colloidal fraction from one sugar sample examined by the Bureau of Chemistry was found to have a specific rotation of—36°, which is approximately the value for the specific rotation of a gum prepared at the Bureau by Paine and Walton by dialysing beet molasses.

This gummy impurity of the sugar did not reduce Fehling solution until after hydrolysis by hydrochloric acid. This indicates that it is a polysaccharide, probably extracted from the beets in the process of diffusion.

The presence of uneliminated colloidal impurities is not only responsible for various sugar factory difficulties, such as poor filtration, bad vacuum-pan boiling, and delayed crystallisation, but it is also a most common cause of off-colour sugar. These impurities may be of an inorganic as well as of an organic nature. In Demerara much colloidal silica finds its way from the soil into the cane juices and causes trouble in the factory by interfering with the clarification and by producing scale upon the coils of the evaporators. Superheating the juice before clarifying with lime has been found to eliminate much of this colloidal silica, and to cause a marked improvement in the yield and quality of the raw sugar produced.

The liming of juices for clarification has for centuries been one of the most important steps in sugar manufacture, yet until very recently but little effort has been made to place the control of this operation upon a strictly scientific basis. Owing to the well-known destructive action of alkalis upon reducing sugars, with the formation of dark decomposition products, great care is needed in the application of lime to sugar-cane juices. The theoretical quantity of lime for neutralising the free acid in a given quantity of cane juice may be measured, but, because of imperfect facilities and the lack of opportunity for a rapid intermixing of lime and juice, there may occur local zones of liquid that are over-and under-limed. Thus considerable damage may result from the destruction of reducing sugars at one instant by over-liming and from the inversion of sucrose at the next instant by under-liming.

Owing to the fact that the juices expressed from the cane are of constantly varying acidity, it has been impossible to devise a perfectly satisfactory continuous method of liming. The operator who tests the reaction of the juice with phenolphthalein at given intervals may obtain an average ratio of lime for a given flow of uniform juice that is fairly satisfactory, but if the reaction or rate of flow of the juice

should suddenly change he may not detect the difference of conditions in time to prevent damage.

To correct the defects of this symtem of control the Bureau of Chemistry recently conducted experiments in Porto Rico upon continuous electrometer p_H measurements of cane juices by means of an automatic recorder. It was found possible by means of this device to detect rapid fluctuations in the reactions of juices which were not revealed by the intermittent methods of measurement, whether by titration or by p_H determination. With the reading of the automatic recorder constantly before him, the operator was able to adjust the lime control the instant a change in the reaction of the juices was indicated. The results obtained by the use of this new instrument were exceedingly favourble, th extreme fluctuations in reaction, due to temporary or locel overliming and underliming, disappearing. The existeance of a continuous permanent record of the daily juice reactions is also of value to the factory superintendent for reference. The next obvious step in clarification control will be an extention of the automatic recorder to an automatic device for regulating the addition of lime to the juice. In fact, the accomplishment of this ideal is well on the way to realisation.

The recent war gave an impetus to the manufacture of white sugar on tropical plantations. Some enthusiasts predicted that in a very few years all the cane-sugar refineries of the world would have to go out of business, since they deemed it far more economical to make white sugar right where the cane was grown. This prophecy has never been realised for the reason that no plantation has yet found it possible to manufacture white sugars equal in purity and uniformity of grade to refined sugars Nothwithstanding, however, the failure of the prediction regarding the expansion of the tropical white sugar industry, there has been a vast improvement since the war in in the quality of the raw sugars produced upon cane plantations.

This improvement in the purity of plantation raw sugars has not, however, always been accompanied by an improvement in keeping quality, which is a characteritics

of the utmost importance when the output of a factory has to be stored over long periods of time. The keeping quality of a sugar is conditioned by two factors—the moisture content and the purity. Sugars of high purity and high moisture content deteriorate very rapidly as a result of the activity of yeasts, moulds, and other micro-organisms. The higher the percentage of soluble impurities in a sugar, the greater the amount of moisture it can retain without danger of deterioration. Various tables and rules have been devised for predicting the keeping quality of a sugar. The best known of these is the so-called "factor-of-safety" rule of the Colonial Sugar Refining Company of Australia, according to which the moisture of a sugar must not exceed one-half the non-sugar if the product is to keep. Experiments conducted over a long period of years at the New York Sugar Trade Laboratory upon raw cane sugars of West Indian origin showed that the moisture should not exceed one-third the non-sugar. This is now the generally accepted figure.

But like all other rules the "factor-of-safety" formula must be intelligently applied. A sugar conforming to the requirements of the formula will not deteriorate only so long as there is no disturbance in the even distribution of its moisture. Let there be, for example, an uneven distribution of temperature in the sugar, and the moisture will be forced to migrate from the warmer to the cooler portion of the mass. There will then be produced zones of sugar with a moisture content above that prescribed by the safety factor, and in these places deterioration will at once begin.

The risk of moisture migration in stored sugar increases with the size of the containing parcels. Smaller packages offer a proportionately larger radiating surface for the same weight of sugar than bigger ones, and hence tend to hold the mass at a more uniform temperature, with less probability of dangerous high moisture regions, being formed. It is for this reason that the storing and shipping of raw sugar in large bulk is a hazardous proposition.

Several instances have been recorded where the deterioration of raw sugars proceeded so rapidly that spontaneous combustion of the product took place with

almost explosive violence. The evolution of so much heat, far exceeding the tolerance of the most resistant micro-organisms, is difficult to explain. The first stages of the process are unquestionably fermentative. During this phase the product may reach a temperature of 70° or 80° which approaches the thermal death-point of the organisms involved. The second stages of the process, when the temperature mounts rapidly upward to the point of ignition, are of a vastly different character. Whether this results from the rapid oxidation of some unsaturated fermentation product, from the sudden decomposition of some unstable endothermic compound produced under anærobic conditions, from the effect of some highly reactive catalytic agent, or from some violent exothermic reaction of an unknown character is a matter upon which at the present time we can only speculate.

Spontaneous decompositions very similar to fermentations may take place in concentrated syrups and molasses under absolutely sterile conditions. For twelve years I have had under observation several samples of molasses that have undergone a slow inversion of sucrose, a gradual destruction of reducing sugars, and a slight evolution of gas, with a constantly increasing darkening of colour. Bacteriological examinations have failed to give positive indications of the presence of yeasts or other organisms. The change seems to be a subdued example of the old hot room froth fermentation, which is not bacterial, and is now attributed by some investigators to a reaction between amino acids and reducing sugars. It is known that under favourable conditions this so-called froth fermentation of molasses may proceed violently, with the evolution of a large volume of gas and enough heat to carbonise the entire contents of the tank.

The Sugar Industry.

The application of strict scientific principles has been followed more energetically in beet sugar manufacture than in cane sugar manufacture. This we would expect, for the beet industry was developed in the highly civilised European countries, where skilled labour was abundant,

and the cane industry was maintained in primitive tropical countries, where labour was shiftless and unskilled. In 1852, taking the whole supply of the world, six times as much cane sugar as beet sugar was manufactured. Beet sugar kept gaining, however, until by 1884 the production of the two kinds of sugar was about equal, a little over 2,500,000 tons each. Beet sugar then took the lead, until in 1899 its production was about 5,500,000 tons, against a cane sugar production of about 3,000,000 tons. Then came the ending of the Cuban war, and with it the application of the scientific principles worked out for the beet industry to the dilapidated cane factories of Cuba and Porto Rico. Modern methods of manufacture had also been busy reorganising the cane industry in Hawaii, Java, Australia, and other countries. The production of beet sugar in 1901 reached nearly 7,000,000 tons, and since then has remained practically stationary. But the increase in cane sugar production, however, has gone forward each year by leaps nd bounds. In 1907 the cane had caught up to the beet, the production of each kind being a little over 7,000,000 tons. In 1908 cane sugar was over 600,000 tons ahead, and in 1909 nearly 2,000,000 tons ahead, out of a total world's production of about 15,000,000 tons.

During the World War the beet sugar industry of France, Belgium, and other European countries suffered a serious setback, large fertile sugar beet areas having been within the zone of conflict and many hundreds of factories destroyed. In order to make up the deficiency thus caused in the world's sugar supply, a great impetus was given to the cane sugar industry of the tropics. At the close of the war the total production of the world's beet sugar had fallen to 3,259,380 tons, while that of cane sugar had advanced to 11,957,232 tons, over 78 per cent. of the entire sugar production. Since 1919 the beet sugar industry of Europe has been rapidly recovering, the total production of the world's beet sugar for the present crop year (1925—1926) being 8,287,000 tons which is 33.9 per cent. of the entire sugar production of the world (24,398,214 tons).

The future development of the world's sugar industry will probably be more extensively confined to sugar-cane

growing countries. This is due principally to the lower cost of producing cane sugar, because of the cheaper labour of tropical countries, and the much greater yield of sugar per acre which the cane gives over the beet. Under the best systems of cultivation and manufacture, such as are found in Hawaii and Java, more than four tons of sugar can be produced per acre. Germany, which leads in the production and yield of beet sugar, can raise barely two tons of sugar per acre. Yet, notwithstanding the natural advantages possessed by the sugar cane, the production of beet sugar is bound to increase for many years to come. The sugar beet, as a root-producing plant of deep-feeding character, plays a most beneficial part in the systems of crop-rotation which are best suited to diversified farming. It is a crop which from the standpoint of both agriculture and national economy should always meet with the most favourable consideration in countries which, like the United States and Canada, are climatically suited to its best development.

CAUSES OF INFERTILITY IN SOILS IN RELATION TO BACTERIAL ACTION.

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Infertility as a negative term suggests the absence of elements required for fertility; it is necessary, however, to realize that infertility may result from the presence of substances or conditions inimical to the growth of plant.

The causes of infertility in soils may, therefore, be divided into two main groups or classes:—

(1) Those associated with the absence of substances or conditions necessary for fertility.

(2) Those depending for their action upon the presence of deleterious substances or conditions liable to interfere with the growth of plants.

To the layman an infertile soil suggests either a desert tract entirely bare of vegetation, or perhaps an area at one time under cultivation but now abandoned because of its infertility. The agriculturist, however, has a much higher standard of fertility in mind ; to him an infertile soil is one which it does not pay to cultivate or at the best is of such poor quality or condition that nothing but necessity would make him spend his time and labour in doing so. To this latter class belongs a large proportion of the arable lands now under cultivation ; these have come down from their original condition of high fertility as virgin soils to their present state of comparative infertility as a direct result of the artificial conditions of plant growth to which they have been subjected during years of crop cultivation. It is with this class of soils requiring highly expert treatment and knowledge that we are mainly concerned, those in which the degree of fertility is so low that relatively small causes, or infertility factors may at any moment reduce their yield below the point at which it ceases to pay to cultivate them. It is therefore of prime importance for the agriculturist to be well acquainted with the various and numerous causes of infertility which may reduce the condition of his soil and the amount of his crop below the paying minimum.

One of the most common and well understood causes of infertility is the lack of a sufficient supply of those ingredients in the soil which are necessary for fertility. It is impracticable here to deal with these except to point out that an insufficiency of plant foods not only affects the growth of crops directly but also indirectly by limiting the activities of those bacteria upon which fertility depends. This is more especially the case with reference to the supply of humus, for reasons to be dealt with later.

Water supply of course is a vital factor and must be taken account of both from the point of view of defi-

ciency and of excess ; this implies management of the soil in such a way as to avoid both deficiency or excess of water, the latter with its concomitant result of lack of air being especially conducive to infertility by reason of its effect on bacterial activities in the soil.

On the other hand, infertility may result from the presence of harmful substances in the soil such as excess of organic acids or of alkali salts and in some cases of neutral salts including chlorides, sulphates and nitrates. With these causes of infertility we are not for the moment concerned, but others more generally distributed exist which are of great importance although perhaps not fully recognised as such. Under certain conditions toxic bodies are produced in soils and their influence upon fertility depends largely upon the quantities in which they are present. Generally speaking, their production depends upon the existence of anærobic conditions due to water-logging and is the result of bacterial action of the class associated with this condition. In order to understand not only how such bacterial action takes place but to arrive at an adequate conception of its importance as a factor in soil infertility, it is necessary to know something about that class of soil organisms known as anærobic bacteria. There is no definite dividing line between ærobes and anærobes, that is between such bacteria as require oxygen and those that do not ; there is an intermediate class the members of which can tolerate varying degrees of æration or the reverse and even those species which are apparently obligate anærobes can function in presence of small amounts of oxygen, especially in cone junction with certain aerobic species whose activities reduc- the oxygen tension in the soil water. The fact that it is necessary to bear in mind is that soil conditions, so far as anærobism or the reverse is concerned, determine whether anærobic or ærobic bacteria shall predominate in such soils with results which will vary in accordance with the characteristic differences of their action.

Anærobic bacteria and anærobic fermentations are generally associated with unhealthy conditions of one kind or another ; thus putrefaction as opposed to decay is pro-

duced mainly by anærobes, which are also responsible for most septic conditions and incidentally for tetanus.

Anærobic bacteria in soils produce infertility in several ways:—

(1) By the production of colloidal bodies resulting from decomposition of organic matter, plant residues, roots and stubble, dead leaves, green manures, oilcakes and cattle manure. These colloidal bodies take the form of bacterial waxes or slimes which coat the surfaces of the soil particles and tend to block up the pores of the soil, thus interfering with æration and drainage. It is of interest to note that the coating of the soil particles both organic and inorganic with bacterial wax has the effect of protecting them from further bacterial action, thus reducing the rate and amount of such important processes as nitrification or organic matter and solubilization of mineral phosphates. The fertilizing action of such partial sterilizing agents as toluene can be partly attributed to their solvent action upon this coating, exposing fresh surfaces to bacterial action ; a similar result is produced by the mechanical rubbing and grinding action of cultivation processes such as ploughing and harrowing, and also by the aeration and desiccation resulting from the latter which tends to destroy the colloidal condition of the bacterial slimes. It is important to realize that anaerobism in soils tends to increase by reason of the fact that the anaerobic classes of bacteria, whose growth and preponderance results from the prevalence of this condition, are themselves capable of contributing to and increasing it by the production of colloids; thus the vicious circle is completed and this tendercy becomes of great practical importance.

(2) by the production of toxic bodies which reduce fertility either (*a*) directly as plant poisons, or (*b*) indirectly by their interference with nitrification.

The first case involves exceptional conditions such as waterlogging, or a soil of naturally high non-porosity such as a heavy clay.

Waterlogging in the presence of organic matter results in the production not only of colloids but of plant poisons by anaerobic bacteria. The presence and action of such

poisons can be demonstrated by watering platnts with extracts of anaerobically incubated soils, apart from the well known effects of attempting to grow plants in soils in which drainage has been interfered with or in which anaerobic fermentation of organic matter has been carried out to excess.

The maize plant affords an interesting case of natural provision against poisoning by organic toxins resulting from soil anaerobism; the secondary aerial root system commonly found in this plant is a provision against the absorption of toxins resulting from anaerobic conditions due to excess of moisture in the subsoil, which the plant is able to avoid by putting out secondary roots into the surface soil at that period of its growth when flooding of the soil is liable to occur.

Intoxication of the seedling maize plant is also liable to occur in wet soils as a consequence of bacterial invasion of the seeds whilst the latter is still attached to and is providing nutriment to the young plant. This form of damage is probably due to mechanical injury to the seed-coat generally as a result of insect attack.

A special case of anaerobism is that produced by the growth of grasses, the closely interwoven roots and stoloniferous stems forming a sod or layer not only relatively impervious but giving rise to extra quantities of CO_2 in the surface soil by their decay. There is reasons, to believe that under certain conditions especially in wet seasons, toxins are formed as a result of the decay of parts of this growth; this result may be noticed where cut grass from the mower is allowed to lie during wet weather on the surface of turf, which is completely killed by this treatment and may not recover for months afterwards. In addition, the partially anaerobic conditions induced in the soil interfere with nitrification and consequently reduce fertility; this effect may be observed and measured and is probably responsible for the very marked and well known inhibitory action of grass upon the growth of trees.

INDIRECT ACTION OF TOXINS ON FERTILITY.

Nitrifying bacteria are known to be highly susceptible to the action of toxins of various kinds. Soil sterilized by

heat is not only lacking in nitrifying organisms but when these are re-introduced by inoculation their normal action is inhibited by toxic bodies produced by the action of heat upon the organic matter present. Similarly anaerobic incubation of soil results in the production of toxins having an inhibitory effect upon nitrification, and in addition cases have been observed where anaerobic conditions in a soil have resulted in the multiplication of specific bacteria, capable of inhibiting nitrification by the toxic action upon the nitrifiers of the bye-products of their metabolism, This action is most pronounced in presence of organic matter. which will fail to nitrify in a soil under reduced air supply, whereas the same soil under similar conditions of aeration will nitrify ammonium sulphate. That this inhibition of nitrification is due to the production of toxins from the organic matter is shown by the fact that nitrification does not immediately take place in a soil treated in this manner when complete aeration is provided subsequently, but only commences after a period of time (some ten to fourteen days) sufficient to allow of destruction by oxidation of the toxins thus formed.

In this case therefore, we have an instance of infertility caused by interference with nitrification and resulting from the action of toxins not present in sufficient amount to produce directly harmful action on plants. The importance of recognizing this source of infertility lies in the frequency of the occurrence of the conditions giving rise to it. Any condition of the soil causing any degree of anaerobism will encourage the growth of those classes of bacteria responsible for the effects described above; such conditions may arise from improper soil management, such as ploughing when too wet, or from physical properties of the soil itself rendering it peculiarly liable to this source of infertility.

RELATION OF THE ABOVE FACTS TO AGRICULTURAL OPERATIONS.

Agricultural operations consist mainly of :—

(1) Cultivation, *i.e.*, stirring the soil.

(2) Irrigation or drainage, *i.e.*, controlling the water supply and with it the air content.

(3) Manuring—the addition of plant food in a suitable form.

(4) Selection of suitable crops and of improved varieties to make the most of natural fertility or to minimize the effects of natural infertility.

Cultivation :—The principal function of cultivation is to regulate the water supply of the soil and promote formation of available, *i.e.*, soluble plant food, especially nitrates. Nitrification depends upon a suitable balance between air and water supply and upon removal or oxidation of certain by-products of bacterial metabolism : if this is not provided for, either nitrification does not proceed at a sufficient rate or the reverse action, *i.e.*, reduction of nitrates by bacterial action occurs, the bacterial balance being then against the accumulation of nitrates sufficient for fertility. Therefore the operations of ploughing, harrowing, rolling and inter-cultivation must be carried out with a view to maintaining in the soil such conditions of water supply and aeration as will promote nitrification at that time of year when the growing crop is ready to absorb it. Hot weather cultivation has other functions besides that of killing out weeds ; this operation has a very decided action in lowering the percentage of anaerobic, bacteria, destroying many of the deleterious by-products of their growth including some colloids, by oxidation and desiccation, and probably strongly discouraging certain infective and pathogenic organisms such as ***Ps tritici*** and ***Bact solanacearum.*** Ploughing wet has an extremely bad effect on many soils ; the results is infertility due mainly to destruction of the mechanical condition or tilth, this is brought about largely by the operation of a most important factor in soil physics, namely the film of air which coats and closely clings to the soil particles and is only displaced with difficulty ; this air film plays an important part not only in the biological activities of the soil, but in maintaining its physical condition, and exercises a vital influence in preventing waterlogging of the soil particles. Ploughing the soil when it is dry, by breaking up the particles, increases the area of their surfaces and with it the content

of the air held in the form of the air film upon these surfaces. Ploughing when wet, however, abrades the air film and rubs it off, replacing it with water, removing the permanent air supply and bringing the soil particles into close and adhesive contact. The puddling of clay such as is effected in a pug mill depends upon the action.

Apart from the deleterious influence of compaction upon the biological processes of soil especially nitrification, it must be remembered that plant roots have to penetrate soil by sheer mechanical pressure and that many crops fail to do this in soils or subsoils whose texture is so close as to present mechanical resistance too great for easy penetration ; the "pan " liable to occur in arable soils at the lower limit of cultivation is a familiar instance of this condition.

Drainage.—The principal object of drainage is to prevent the formation or persistence of an anaerobic conditions in the soil ; it is unnecessary to repeat the reasons for considering anaerobism fatal to fertility, but it may be pointed out that in a soil of average texture and fertility not only may the whole existing supply of nitrates be destroyed in a few days' time by the existence during that period of anaerobism due to waterlogging, but conditions may be set up which will seriouly interfere with the process of nitrification after removal of the excess of water.

Irrigation.—Where irrigation is the standard method of water supply for the crops, knowledge of the infertility factors above described is of even greater importance than in unirrigated areas. Control of the water content of the soil not only places in the hands of the cultivator the power of supplying the water requirements of his crop, but makes it essential that he should possess all the information available as to the relation between soil moisture and the numerous and complicated biological processes making for fertility or the reverse, and dependent on appropriate or mistaken use of this control. As the writer pointed out in a paper in the ***Agricultural Journal of India***, there is great need for research and investigation into the water requirements of soils under irrigation ; such enquiries could only be effectively carried out in irrigation areas and must

give due weight to the biological factor. It is probable that the highly important problem of natural fixation of nitrogen in Indian soils is more likely to be solved by study of irrigated than unirrigated soils, and the results of the application the solution will most probably be more readily attained in the former.

Manuring.—The practice of manuring is a recognition of the depletion of soil fertility by the artificial cultivation of crops. It is of course inpossible here to deal with this large subject in any way except to mention one or two points in connection with the relationship between the use of manures and the action of soil bacteria. We may consider as examples the supply of available nitrogen and phosphates as of practical interest and importance.

Nitrogen.—Reference has already been made to the conditions, both favourable and the reverse, whlch occur in soil and which influence the conversion of unavailable organic nitrogenous food into nitrates. It has been pointed out that suitable conditions so far as air and water supply in the soil are concerned must be provided by appropriate cultivation; it it also necessary to know something about the capacity of particular soils to deal with the sources of nitrogen in question, *i.e.*, whether the soil af an area under manurial treatment is capable of nitrifyng the material available for this purpose. This introduces the interesting fact that instances have been found of soils in wnich not only does nitrification not occur, but examination has shown that nitrifying organisms are absent altogether. Although such soils are in most cases of a low grade of fertility and will carry only certain crops, in other instances such as some tea soils, the crop flourishes and responds to ordinary manurial applications in such a way as to suggest that nitrate nitrogen is not necessary to its growth or well-being. This of course is also the case with rice under swamp conditions, to which crop nitrates are apparently not only unnecessary but actually harmful, except in the seedling and in the latest stages of growth. In certain soils from the neighbourhood of Ranchi containing no nitrifiers I have found it possible to induce nitrification by artificial inoculation with nitrifying bacteria, but this

improvement would probably not be a permanent one unless intensive cultivation and applications of lime were maintained over considerable periods.

Another consideration arises in connection with the nitrification of organic manures, this being the suitability of the latter for the process. Observation of the nitrification rate of various nitrogenous materials show a wide variation in their suitability as evidenced by this rate; *mahua* cake for example only nitrifies in soil after prolonged periods of time, probably owing to its content of saponin. In practice, it is important not only to keep this in mind, but to be aware of the fact that nitrification is inhibited both by unsuitable soil conditions and by the application of excessive amounts of organic nitrogenous material. Other important factors come into operation in this connection and must be taken into account, but time forbids reference to them except to mention the possibility of loss of nitrogen as nitrate under conditions where the nitrification rate is so high as to lead to removal of nitrate by leaching by rain water passing through the soil. For this reason it is frequently advisable to apply dressings of cake in separate doses during the growing season of the crop, in place of all at one time.

Phosphates.—The availability of phosphatic manures is intimately connected with bacterial action in the soils to which they are applied. Two distinct styles of bacterial activity are concerned: (1) those which tend to solubilize otherwise insoluble phosphates; (2) those whose action results in diversion of phosphate from the supply originally available for the plant.

(1) It is probable that a large proportion of the naturally available, because soluble, phosphate in the soil is in this condition as a result of acid re-actions set up by bacterial activity, either by formation of organic acids or of carbon dioxide. It was originally considered that this action, generally associated with the decomposition of plant residues, such as green manures, oilcakes and cattle manures, resulted in the direct supply of soluble phosphates to the crop, and might be intensified by the method of composting mineral phosphates with organic matter. Experience,

however, has yielded disappointing results with this method when utilized with the intention of obtaining supplies of soluble phosphates, and it has consequently been largely abandoned; this in my opinion is a mistake, as the apparent failure of the method is due to the appraisement of the results in terms of directly soluble phosphate as is the practice with superphosphate, whereas so far as work at Pusa on this subject has gone it appears that changes in the condition of the original insoluble phosphate due to bacterial fermentation in the compost, take place leaving a certain proportion in a relatively available condition in the form of organic phosphorus compounds, probably constituents of the bacterial cells themselves. Evidence exists leading to the conclusion that the $P_2 O_5$ held in this combination can serve as plant food under soil conditions, either directly owing to the death of the bacterial cells or to later changes in the soil of an indeterminate nature. My present opinion based on field and laboratory experiments is, that bacterial action under suitable conditions is able to convert phosphate into organic combination and remove it from those influences which would otherwise tend to produce chemical reversion to the insoluble tricalcic condition ; this organic combination will later present a source of phosphate food of relatively higher availability than the tricalcic form resulting from purely chemical reversion, or existing as such originally. The practical agricultural method of securing this result depends merely upon the provision of adequate soil moisture and sufficient organic matter to promote vigorous bacterial growth and activity ; this is one of the principal functions of such operations as green-manuring.

A more specialized style of solubilization of phosphates occurs in the case of that effected by sulphur oxidizing bacteria. Time does not permit of anything more than reference to this process which I described in an article in the "Agricultural Journal of India" (January, 1924) and at the last meeting of the Board of Agriculture at Bangalore. It is of course an artificial method depending on the use of sulphur and bacterial cultures capable of producing sulphuric acid therefrom, but it is of interest to note

that the method is now being tried on a commercial scale as a source of phosphatic manure.

(2) With reference to that class of bacterial action resulting in removal of phosphate from the root range of the growing crop it must always be remembered that bacteria are plants and as such will compete with the agriculturist's crop for plant food in the soil. We have seen that this happens in the case of nitrates and there is reason to believe that it is an equally important phenomenon as applied to the supply of phosphates ; thus superphosphate when applied to a soil is partly taken up by the crop, partly reverted by chemical action, and partly absorbed by bacteria. As we have seen above, there is reason for supposing that this last portion remains relatively available as compared with that which has undergone chemical reversion, so that there is no reason for treating this form of bacterial activity as one likely to produce infertility in the soil.

On the other hand practical experience shows that in our Pusa soils the combination of green manures with superphosphate produces the best results, so thaton the whole we may consider bacterial action in the soil as a favourable influence so far as supplies of available phosphate are concerned, and the aim of the agriculturist should therefore be to encourage such activity as much as possible. This can be done mainly by maintaining adequate supplies of organic matter, and the inclusion of the usual methods of doing so in agricultural practice forms another instance of a correct method based on empiricism derived from experience.

The selection of crops and use of improved varieties is too large a subject to be dealt with here. One point may be referred to and that is the selection of varieties with special reference to the depth of root range of the plant ; here we come in direct contact with soil conditions involving degrees of anaerobism or the reverse, varying in accordance with the character of the soil and its agricultural treatment. Knowledge of the unfavourable effects of anaerobism such as have been described above will not only serve as an additional incentive to the use of such agricultural op-

erations as will tend to diminish this condition, but may lead to the use of shallower rooted varieties in situations where soil and climate may render this additional precaution necessary.

In conclusion, it may be emphasized that so far as soil fertility is concerned, this condition or its opposite can never be ascribed to one simple cause alone but is associated with the interaction of several. It is incorrect to say, for example, that lack of oxygen causes infertility only because plant roots require oxygen for healthy growth; we have seen that conditions in the soil producing an insufficiency of air tend to cause infertility through the combined operation of a number of factors, some positive such as the production of toxins and of colloids by anaerobic bacteria, and others negative su ch as the failure to form nitrates for want of sufficient oxygen to maintain the proper bacterial balance in the soil. The complete investigation of the reactions and especially the bacterial activities underlying and ultimately responsible for the complex changes and conditions in a soil, is essential and necessary for any understanding of the problem of soil fertility ; in this country especially, owing to the high soil temperatures which prevail during a large part of the year, and the correspondingly rapid bacterial changes resulting therefrom, any advance towards solution of this problem must depend upon adequate recognition of the intimate connection between soil fertility and soil bacteriology.—Agricultural Journal of India, Vol. XXI, Part 2.

Meteorological Data 1925.

BOTANIC GARDENS, GEORGETOWN.

1925. MONTHS.	Rainfall. Inches.	Number of Days of Rain. Under .10 in.	.10 to .50 in.	.50 to 1.00 in.	1.00 to 2.00 in.	Above 2.00 in.	Total Days.	Evaporation Inches.
January	1.93	4	7	...	...	...	11	5.27
February	.85	6	...	1	...	...	7	5.49
March	.56	3	1	...	...	...	4	7.06
April	.48	2	1	...	...	...	3	7.69
May	12.94	...	9	3	4	1	17	4.83
June	20.82	3	8	3	5	3	22	3.65
July	11.60	6	6	3	6	...	21	4.44
August	9.82	8	5	3	4	...	20	5.22
September	2.77	4	8	1	...	...	13	5.37
October	1.48	3	4	...	...	...	7	5.78
November	3.20	4	3	2	1	...	10	4.76
December	13.87	5	9	4	5	1	24	3.58
TOTALS.	80.32	48	61	20	25	5	159	63.14

Stations.	Wettest Day.	Rainfall. Inches	Hottest Day.	Temperature.
Botanic Gardens, Georgetown ...	17th June	4.18	27th July, 20th Oct., 14th Nov.	90.0
New Amsterdam Public Gardens...	17th June	4.16	27th July, 13th Sept	93.5
Onderneeming Essequibo ...	17th June	3.50	9. 12. 13. Apl. 14. 16. 21. Sept	92.0
Morawhanna N.W.D. ...	3rd July	4.30	...	...

AIR TEMPERATURE AND HUMIDITY IN THE SHADE BOTANIC GARDENS, GEORGETOWN, 1926.

Months.	Air Temperature.			Humidity.
	Maximum.	Minimum.	Mean.	Mean.
January ...	85.4	74.8	80.1	76.7
February ...	85.8	75.3	80.5	74.5
March ...	86.5	76.1	81.3	69.3
April ...	87.7	77.2	82.4	68.9
May ...	86.6	76.9	81.7	76.3
June ...	85.4	76.3	80.8	81.9
July ...	86.1	75.5	80.8	79.3
August ...	86.4	75.7	81.0	79.8
September ...	87.8	76.7	82.2	79.9
October ...	88.1	76.9	82.5	77.0
November ...	88.1	76.5	82.3	77.7
December ...	85.2	75.5	80.3	82.3
Mean ...	36.6	76.1	81.3	77.0

ATTENDANCES AT THE DISTRICT GARDENS

Year.	Bourda.	Belfield, E. Coast.	Stanleytown, New Amsterdam.	Suddie, Essequibo.	Den Amstel.	Houston, E. Bank.	Wakenaam.	Total Attendances.
1912 ...	5,514	4,395	3,302	2,100	2,544	2,156	1,718	21,729
1913 ...	5,156	4,535	2,519	3,399	2,568	1,836	1,319	21,332
1914 ...	4,243	3,869	2,443	3,025	1,791	1,653	1,533	18,57[illegible]
1915 ...	1,123	1,006	769	59	503	339	401	4,209
1916 ...	4,705	1,161	1,510	225	623	2,251	1,297	12,026
1917 ...	4,991	2,820	1,366	3,297	1,186	2,564	1,663	17,086
1918 ...	4,834	3,081	1,653	2,671	2,162	2,790	2,067	19,258
1919 ...	4,769	2,425	1,582	2,798	1,851	2,480	1,556	17,461
1920 ...	6,285	2,312	1,665	2,525	2,532	3,228	2,148	20,695
1921 ...	5,671	1,968	1,642	2,629	1,949	2,539	1,610	18,008
1922 ...	3,557	1,841	1,105	1,593	1,525	1,522	1,397	12,950
1923 ...	4,038	2,780	1,595	1,934	1,953	2,137	1,951	16,388
1924 ...	4,123	2,827	1,103	1,789	1,678	2,146	1,664	15,330
1925	3,317	2,755	1,580	1,819	470	1,663	1,597	13,201
1926 * ...	1,732	2,627	1,219	2,172	364	1,268	1,600	
1st quarter	545	935	410	494	62	175	614	
2nd quarter	363	561	321	432	37	225	379	
3rd quarter	444	538	65	448	85	401	300	
4th quarter	380	593	423	798	280	467	307	

* Decrease in attendances caused by very unfavourable weather conditions.

EXPORTS OF AGRICULTURAL AND FOREST PRODUCTS.

Below will be found a list of the Agricultural an Forest Products of the Colony exported during 1926.

The corresponding figures for the two previous year and the average for the seventeen years prior to that are added for convenience of comparison.

Product.	*Average 1907-23.*	*1924.*	*1925.*	*1926.*
Sugar, tons	98,677	85,896	97,714	84,659
Rum, gallons	2,616,395	769,308	1,148,119	789,642
Molasses, gallons	113,338	1,160,757	1,345,243	2,017,862
Cattle-food (Molascuit) tons	4,291	1,102	1,268	1,075
Cacao, cwts.	346	None	None	None
Citrate of Lime, cwts.	154	None	None	None
Lime Juice, gals.	* 10,286	9,785	8,430	4,974
Essential Oil of Limes, gals.	* 366	396	306	277
Coconuts, thousands	1,690	1,560	1,363	816
Coconut Oil, gals.	* 22,058	21,804	30,394	18,778
Copra, cwts.	1,589	16,508	17,278	34,111
Coffee, cwts.	2,837	4,581	5,964	6,904
Kola-nuts, cwts.	12	None	None	None
Rice, tons	6,566	4,470	6,918	2,914
Ricemeal, tons	713	None	None	None
Cattle, head	656	391	514	44
Hides, No.	5,041	8,902	9,801	7,916
Pigs, No.	690	427	889	550
Sheep, head	65	37	14	None
Balata, cwts.	10,593	12,234	8,079	5,384
Charcoal, bags	60,033	42,040	3,265	38,504
Firewood, Wallaba, etc., tons	8,095	6,477	6,143	7,716
ums, lbs.	2,900	708	477	2,034
umber, ft.	225,535	180,863	146,561	189,034
ailway sleepers, No.	9,144	39,238	39,779	10,793
ubber, cwts.	66	35	96	307
hingles, thousands	2,394	1,278	1,892	1,312
mber, cub. ft.	120,896	168,454	216,749	313,461

*An average for eight years 1916 to 1923.

No records available prior to 1916.